

WORLD ANIMAL REVIEW

27



1978



A QUARTERLY JOURNAL DEVOTED TO WORLD DEVELOPMENTS IN
ANIMAL PRODUCTION, ANIMAL HEALTH AND ANIMAL PRODUCTS

The process of increasing production efficiency at the farm level is dependent on the removal of impediments, the provision of services and the use of innovations. Research on specific biological factors can pave the way for substantial improvements in performance and productivity. But the large-scale application of biological research findings depends on two factors: the susceptibility or resistance to change of existing systems, and the availability of management information on the benefits expected from an innovation. Socio-economic studies on different production systems are therefore an essential pre-requisite to livestock improvement.

Systems analysis constitutes a more comprehensive approach to such studies. It usually requires the use of models that depend on a large and complex body of information to predict all the consequences of any action or event. Although very few developing countries have yet had the opportunity to simulate systems and study the effect of various inputs on the system as a whole, increasing attention is likely to be given in the future by their research institutes and universities to this approach. Such developments should be encouraged: they would provide a better understanding of existing systems and of the possible relevance of various financial and technological inputs; they would help to establish priorities between research proposals; and they would also assist in evaluating research findings and the innovations that flow from them. Moreover, many of the economic misconceptions resulting from a purely biological approach to animal production research and development will be removed and there would be more ready communication between animal nutritionists, breeders, veterinarians, economists and administrators.



The IV World Conference on Animal Production in Buenos Aires, Argentina, is appropriately devoted to increasing the effectiveness of animal production systems. This issue of World Animal Review, which is dedicated to the Conference, contains an article on systems in addition to the other technical contributions that we normally publish.

We extend our good wishes to the IV World Conference which should provide a unique opportunity for promoting technical cooperation between developing countries.

The Editor

WORLD ANIMAL REVIEW

a quarterly journal on animal production, animal health and animal products no. 27 - 1978

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WORLD ANIMAL REVIEW is a quarterly journal reviewing developments in animal production, animal health and animal products, with particular reference to these spheres in Asia, Africa and Latin America. It is published by the Food and Agriculture Organization of the United Nations. FAO was founded in Quebec, Canada, in October 1945, when the Member Nations agreed to work together to secure a lasting peace through freedom from want. The membership of FAO numbers 144 nations.

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Systems approach to animal agriculture

H.A. Fitzhugh and E.K. Byington

The importance of animal agriculture in the service of man is well documented. In 1970 the total production of food energy from animal products was 574 thousand million Mcal and that of protein 22 million tons (Table 1); these are expected to increase substantially by the year 2000. Apart from producing highly desired food products, animals provide fibre and hides and serve as a major source of work power. Their wastes are also valuable sources of fuel and fertilizer.

Notwithstanding these many contributions, there are many critics of animal agriculture. In support of such criticism, they cite health hazards from saturated animal fats and cholesterol, ecological degradation from overgrazing, inhumane treatment of animals in intensive production systems and, most often, the relative inefficiency of animals as converters of plant materials and other resources.

Sorting through the claims and counterclaims of both proponents and opponents of animal agriculture, it seems clear that meeting consumer demand for animal products must be realized through more efficient management of natural resources. Important decisions will be made by producers, processors, scientists, planners and politicians which will determine animal management and breeding plans, resource allocations, investment strategies, research priorities and government policies with regard to animal agriculture.

Considerable information and experience are available on which to base these decisions. A special need exists to organize this information,

cull extraneous material, and identify what further data are required. The best decisions are likely to be those based on an objective, holistic analysis of animal agriculture systems. Such a management and decision-making strategy is embodied in the systems approach.

Systems approach. Animal agriculture systems are complex. They are composed of and influenced by interacting biological, climatic, social, cultural and economic factors, of which some affecting ruminant systems are represented schematically in Figure 1. Biological components include plant agriculture providing nutrients, disease organisms inhibiting animal performance, and the animals themselves. Socio-economic variables, including disposable income, taste and preference, and government policies, affect supply and demand and ultimately profitability. Clearly, decisions based on simple analyses involving only a few of these factors are unlikely to be effective in improving the efficiency of the system (Fitzhugh, 1978).

Many sophisticated tools — mathe-

matical programming, computer simulation, network analysis, flow diagrams — are commonly employed in the systems approach. However, they are only tools. The systems approach itself is a philosophical basis for problem identification, analysis and decision making.

According to Morley (1972) "[the] systems approach attempts to incorporate in the study all the elements which influence a decision or response, or the understanding of some phenomenon, within defined boundaries." The setting of appropriate boundaries to define the system under study is essential. Exclusion of variables or processes which are critical to the operation of the system or subsystem of interest carries the danger of inappropriate or even erroneous conclusions. Inclusion of non-critical variables or processes unduly complicates analysis of the system.

The definition of the system, including the precision with which variables, constraints and processes are described, will vary with the goals of the analysis, these goals being generally incorporated in the objective function. The objective may be to maximize output

TABLE 1. Food energy and protein production from world ruminant, pig and poultry populations. Annual production for 1970 and projected for year 2000

Product	Livestock units ¹ (Millions)		Food energy ² (Thousand million Mcal)		Food protein ³ (Million metric tons)	
	1970	2000	1970	2000	1970	2000
Ruminants	1 195	1 540	373	638	16	28
Pigs	154	190	144	215	2	3
Poultry	55	68	57	100	4	7
Total	1 404	1 798	574	953	22	38

Source: Fitzhugh et al. (1978).

¹ Livestock unit: cattle = 0.8; buffalo = 1.0; sheep and goats = 0.1; poultry = 0.01; swine = 0.5. —
² Physiological fuel values (PFV), expressed as average Mcal/kg carcass weight: cattle and buffalo meat 2.31; sheep and goat meat 2.0; pig meat 4.2; poultry meat 1.4. PFV, Mcal/kg milk: cattle 0.62; buffalo 1.0; sheep 1.12; goats 0.75. PFV in eggs, Mcal/kg 1.5. —
³ Net protein value (NPV), expressed as g/kg carcass weight: cattle and buffalo meat 105; sheep and goat meat 89; pig meat 60; poultry meat 126. NPV, g/kg milk: cattle 28; buffalo 32; sheep 48; goat 28. NPV in eggs, g/kg, 115.

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Animal systems, such as these dairy systems, may have similar production goals, but different constraints determine optimal management strategy and use of resources. Dairy operations in developed countries commonly depend on capital-intensive technology; whereas, in the developing world, low opportunity cost labour may be substituted. (Winrock International Photo)



of animal products, energetic efficiency or profitability, or it may be to minimize costs or risks of failure. Constraints to system operation (e.g., limitations to available land, labour or capital) must be taken into account in the accomplishment of system objectives. Optimization of programming procedures is useful in identifying strategies if system variables and processes can be described quantitatively (Lasdon, 1970).

The systems approach is not new. Traditional subsistence agriculturists tend to follow a systems approach. Their goal of producing the essentials for survival with minimal risk of complete failure has generally led to highly diversified systems in which animals have an integral role. Land and capital are generally the principal constraints for which low opportunity cost labour partially substitutes.

Traditional smallholders are generally conservative and hesitant to make major changes to systems which evolved under multiple constraints and stresses. Lessons learned the hard way favour small changes with secure fallback positions. Thus, those seeking to "improve" traditional systems would do well to seek first the advice and counsel of the smallholders themselves. This step is at least as important as sophisticated experimentation in understanding how and why the system works.

Improvements should be introduced to animal systems with care and caution. Airline pilots practise for hours on flight simulators before taking responsibility for the lives of their passengers, and generals test their military strategies with computer-simulated war games. These professionals use models to gain necessary experience without the risk of costly failure. It is no less appropriate that decisions and



management strategies for improved animal agriculture be first tested without risk to the lives and livelihood of producers.

Fortunately, the systems approach is increasingly recognized as the appropriate means of improving animal agriculture. Research and development institutions, such as the U.S. Meat Animal Research Center, the U.K. Grassland Research Institute, the International Livestock Centre for Africa, and Winrock International, specifically recognize the systems approach as central to their mission and philosophy.

Modelling animal agriculture systems

Modelling is a powerful tool in the hands of the systems analyst. Some advantages from the use of models include:

- Organization of available knowledge about the system for a clearer understanding of the interacting variables and processes which constitute the system.
- Identification of gaps in knowledge and understanding of the system which must be resolved by further research.
- Stimulation of multidisciplinary approaches to system improvement, and coordination of teams of specialists in a common effort.
- Generation of better understanding of system operation and the necessary experience base for managers and other decision makers with less risk of costly failure.
- Extrapolation, from situations where knowledge of system operation is well known, to new, poorly understood or future situations.

Models are an attempt adequately to approximate the real world system

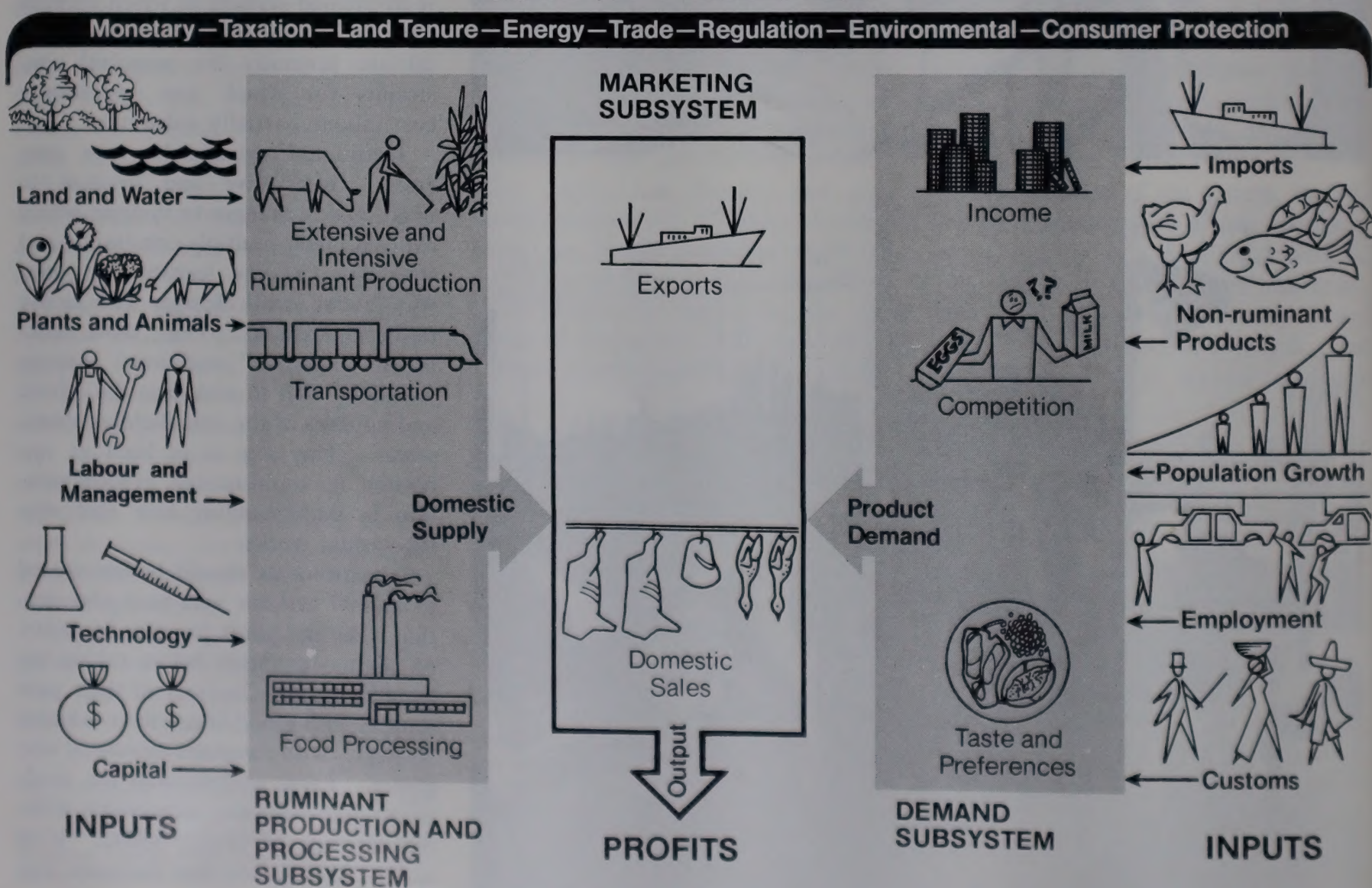
of interest. The important terms are "adequately" and "approximate". Inadequate models lead to erroneous conclusions about the system. However, overly detailed models of the system are confusing and may share the analytical intractability of the real world system.

Physical models. A model aeroplane may be used to simulate real aircraft in wind-tunnel tests. Animal experiments are physical models of the real world system to which results will be applied. And, as is the case for any model, experimental results have little value unless the experimental model adequately approximates the target commercial system. Demonstration models are an effective means of extending new technology.

Schematic models. Graphs, diagrams and charts portraying a real world system are an effective means

Figure 1 Schematic illustration of the complex of interacting biological, economic, social and political components which constitute ruminant production-marketing systems.

GOVERNMENT POLICY



of identifying system inputs, outputs, constraints, processes and goals. These visual representations (Figure 1) assist in organizing available information, setting boundaries, assigning tasks to research teams and describing the system function.

The schematic model indicates the components and functional interrelationships contained within a system, but it does not provide quantitative information about how the system operates and how it will respond under various conditions. The schematic model must be transformed to a mathematical model if this type of information is to be obtained.

Mathematical models. Increased use of mathematical models closely paralleled the development of high-speed computers and supportive software. Computations which would previously have been practically, if not physically, impossible can now be made in seconds. It is not even necessary to understand how computers operate or the underlying logic of programming algorithm. This ease of accessibility to powerful tools is both a boon and a curse to the decision maker.

Much of the concern and criticism of mathematical modelling results from modellers promising too much and delivering too little. Ignorance of the underlying biological, social and economic relationships cannot be compensated for by more and more sophisticated mathematical methods and computing equipment. Even more dangerous is an inaccurate or inadequate model of the system that can transform perfectly good input data into garbage.

The mathematical model is based on a conceptual model. Both are descriptions of the real world, with the mathematical model written in more precise language. The mathematical model is not more accurate simply because it is more precise. Translation of verbal and graphic models into more precise mathematical models requires a clear and exact description of how the system is perceived. The rigorous analysis contained in the formulation of a mathematical model makes such models a valuable tool in systems analysis (Lee, 1973).

Compromise between model comprehensiveness and analytical manageability tends to produce models that are subsystem specific for a particular location. This limitation can be overcome by examining the model's logic and underlying assumptions and by modifying them to reflect the unique features of new situations to which they may be applied.

Model development

Model building and application should be part of a coordinated effort to improve the operation of the real world system in accord with the specified objective function. The model development staff and the management staff interact through the model to identify constraints in the system. Management can recommend possible modifications of the system to remove the constraints, and the model can be used to evaluate the recommended actions. Potentially successful recommendations are then field tested, and the results are used to validate or to modify the model so that it reflects more accurately the real world system being examined.

So much time and effort can be put into developing a mathematical model that it becomes the end product instead of the means to an end. One way to ensure the effective use of a model as a management tool is to maintain continuous communication feedback between the system analysis team and decision makers (producers, processors, politicians and consumers).

Mathematical models of animal systems do not replace but, rather, complement experimental research. Research provides the base data and understanding of biological, social and economic functions necessary for adequate mathematical characterization of the system. On the other hand, modelling animal systems identifies critical knowledge gaps. Sensitivity analyses help determine the precision with which experimental variables must be measured. For example, as pointed out by Cartwright (1977), the biology of weight gain is relatively well understood but not so the biology of weight loss. Considerably more

research on weight loss is needed for effective decisions to be made about feeding high-producing dairy cows, which are often in negative energy balance in early lactation, and for livestock in the tropics where seasonal variation in quantity and quality of forage has a major effect on body weight. Models of such production systems, assuming adequate knowledge of the biology of weight loss, would be an effective tool in the design of strategic nutrient supplementation programmes to increase productivity and efficiency.

Teamwork. A useful technique in modelling animal systems is to partition the system into components or subsystems to allow specialists to concentrate their attention on the components about which they know most. In a beef cattle production model, range scientists and agronomists may concentrate on the feed production models, animal scientists on the cattle production models, and economists on the marketing models. Finally, the component models must be combined, requiring the common efforts of all disciplinary specialists.

This example illustrates a primary advantage of modelling: promotion of effective teamwork. The model serves as a common frame of reference, helping to bridge communication barriers which too often hinder the multidisciplinary efforts critical to practical decision making.

Extrapolation. Models may be used to test strategies or make predictions when it is not feasible to observe or measure the real world system. For example, models were used to estimate feed energy requirements of the world ruminant population — both current and projected — for the year 2000 (Fitzhugh *et al.*, 1978). Comparisons of feed requirements against availability in 15 regions of the world provided a basis for suggesting strategies for improving the contribution and efficiency of ruminant populations.

The potential for extrapolation from known to unknown situations is one of the most valuable opportunities for use of models and also the one most fraught with danger (Joandet and

Cartwright, 1975). Animal systems are influenced by so many factors that it is rarely feasible to conduct controlled experiments under all possible situations. Production and economic conditions can and do change rapidly, and decision makers need to be able to respond to these changes just as rapidly. A major advantage of well-designed, accurate models is that they can be used to test the sensitivity of the system to change. Test results are available in minutes, not in the months or years which would be required to observe response in the real world system. Models of animal systems based on data and documentation from the developed world may serve as initial planning aids in the development of improvement strategies for animal systems in the developing world. The obvious caveat about all such exercises is that both modeller and decision maker must be exceedingly critical of all extrapolations until they have been proved in practice.

Political decisions affecting animal agriculture systems are often made on a "trial-and-error" basis. Unfortunately, the errors may have disastrous consequences for producers and consumers alike. At the present time in the United States, the controversial question of livestock feed additives (diethylstilbestrol, antibiotics, etc.) has entered the political arena. The U.S. Congress is considering legislation to ban some or all feed additives because of their alleged human health hazard. Proponents of feed additives question the wisdom of doing away with practices which increase productivity and efficiency of animal systems at a time when many people of the world are hungry. Headley (1978), using comprehensive bioeconomic simulation models of cattle, swine and poultry systems, examined the projected consequences in the United States of eliminating several important feed additives. Among the conclusions were that intensive poultry and swine management systems would be most changed by the removal of antibiotics, and that the consumer, not the producer, would bear the cost of removing growth promoters from animal rations. The results of this model simulation study will be most helpful

to politicians as they weigh the economic impact of their actions on both producers and consumers of animal products.

Traditional vs. systems approach

The traditional approach to decision making generally involves a model of the system and prediction of expected consequences of the decision. The trouble is that the model is often a poorly specified mental image of the system largely derived from the decision maker's past experiences. Important variables and processes may be unconsciously omitted from this "mental model", with neither the decision maker nor anyone else being aware of the omissions.

Decisions are made on less rational, objective grounds using the traditional approach. They tend to depend on linear extrapolations of the effects of changing single variables. However, most systems are composed of variables and processes which may behave non-linearly with multiple feedbacks and interactions among variables. These variables and processes should be considered simultaneously.

Even when mental models of the system developed through long experience function effectively, the decision maker has difficulty communicating the basis for decisions to others

who do not share the same mental image. Poor communication leads to confusion and controversy, which impede acceptance and implementation of decisions. Even worse, mental models are just as mortal as the person; death terminates a model based on 40-50 years of experience.

The systems approach utilizing quantitative models of the target system avoids many of these problems. Certainly, experience generated from both research and first-hand association with the real world system should supplement the quantitative model. Many important factors — especially socio-cultural variables and processes — are only poorly quantifiable at best, but a clearly specified model makes apparent which values are based on well-documented results, which are best guesses, and which are strictly subjective opinions.

The systems approach does not guarantee that decisions will be popular, easily implemented or even correct. However, they will be based on more objective, rational grounds. Critics of the decision (or the model on which it was based) can pinpoint their areas of concern. New information can be more easily incorporated in models and the consequences of decisions quickly re-evaluated. And, for better or worse, decision makers become more accountable for their actions. ■

References

- CARTWRIGHT, T.C. 1977. The use of modeling to hasten and enhance the application of research information to beef production systems and feedback to research. In *Forage fed beef*, Bulletin 220, Southern Coop. Series.
- FITZHUGH, H.A. 1978. Bioeconomic analysis of ruminant production systems. *J. Anim. Sci.*, 46. (In press)
- FITZHUGH, H.A., HODGSON, H.J., SCOVILLE, O.J., NGUYEN, T.D. & BYERLY, T.C. 1978. *The role of ruminants in support of man*. Morrilton, Ark. 72110, Winrock International Livestock Center.
- HEADLEY, J.C. 1978. Economic aspects of drug and chemical additives. In *Assessment of drugs and chemicals used as additives in livestock feeds*. Washington, D.C., Office of Technology Assessment and Morrilton, Ark. 72110, Winrock International Livestock Center.
- JOANDET, G.E. & CARTWRIGHT, T.C. 1975. Modeling beef production systems. *J. Anim. Sci.*, 41: 1 238-1 246.
- LASDON, L.S. 1970. *Optimization theory for large systems*. New York, Macmillan Co.
- LEE, C. 1973. *Models in planning*. New York, Pergamon Press.
- MORLEY, F.H.W. 1972. A systems approach to animal production. What is it about? *Proc. Aust. Soc. Anim. Prod.*, 9: 1-9.

Sugar cane as cattle feed

T.R. Perston and R.A. Leng

Part I: Nutritional constraints and perspectives

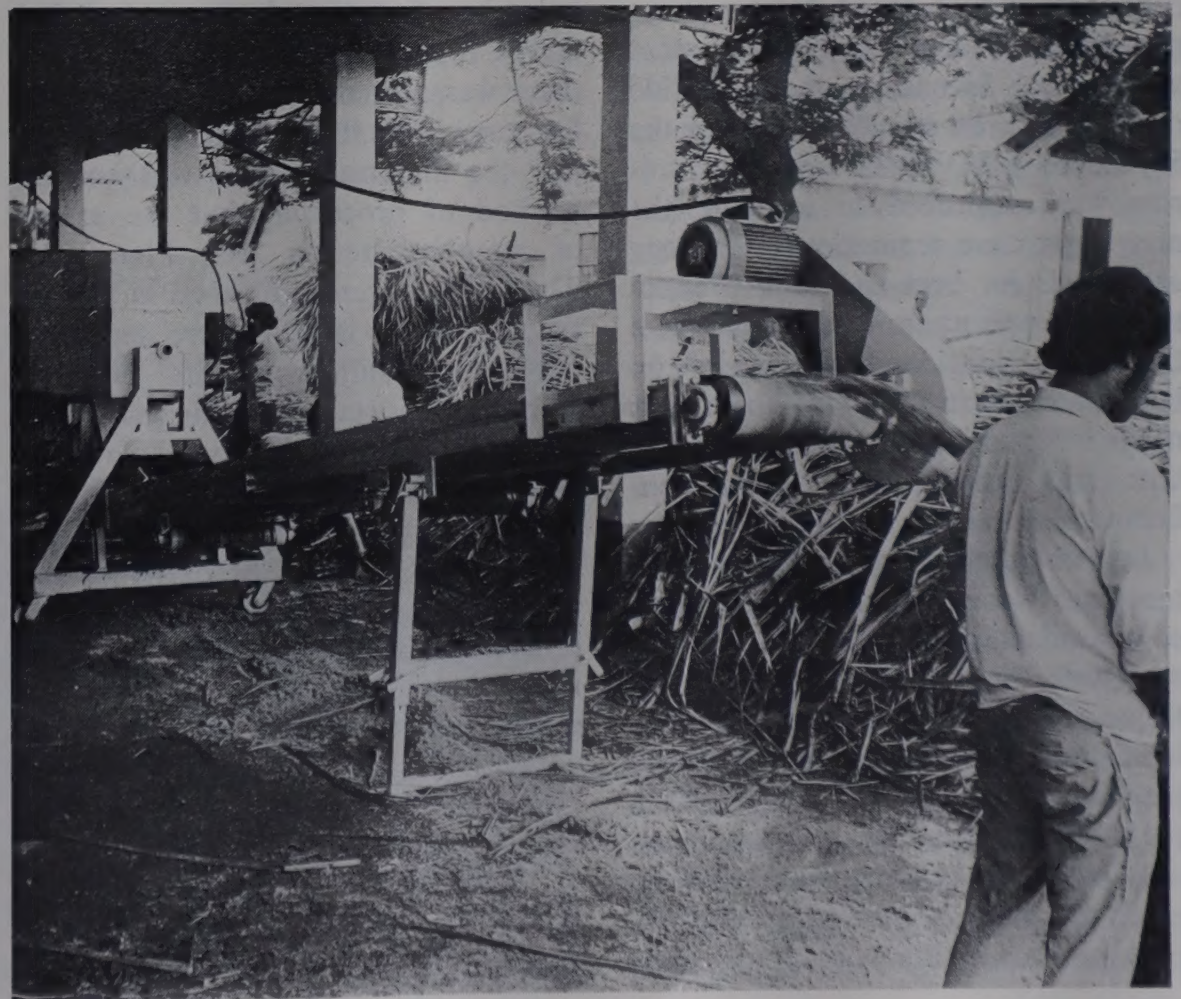
The basic premise of the work reviewed in this two-part article is: that without the accompanying fundamental and applied research sugar cane feeding would never have got beyond the stage of a promising idea, useful in emergencies as in times of feed shortage, but not really a sound basis on which to develop animal feeding systems. The second part of this article, which will appear in World Animal Review 28, is concerned with the commercial application and economics of sugar cane as cattle feed.

production might be only marginally less than that achievable in temperate countries, was indeed remarkable.

After the seminar in Barbados (CIDA, 1973), when the results obtained with derinded cane (comfith) were discussed, interest centred principally on how the new cane separators could be obtained. At that time, the only doubts concerned the cost of the equipment; the problem was one of overcoming the conflict

posed by a patented machine (and the threat of a patented system) with the obvious desire of the inventors to recoup their development costs on the one hand, and its application in an aid-oriented developing world on the other. Almost no one questioned the repeatability of the basic data, because by all known standards a feed with a digestibility of 70 percent (which is superior to that of maize silage) should be easily capable of supporting

Sugar cane separator working in the FAO/UNDP project in Mauritius



When the first information became available concerning the Canadian Development Agency (CIDA)/Barbados Government project on derinding of sugar cane for cattle feeding, it attracted the attention of animal production scientists and development personnel all round the tropical world. The productive potential of sugar cane in the humid tropics was well known, and the prospect of linking this with a cattle feeding system, in which

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liveweight gains of 1 kg per head per day.

It is now five years since the Barbados conference. It has taken this long to identify the constraints on the use of sugar cane in cattle feeding, and to be able to predict responses from feeding it to cattle under the particular circumstances likely to attend its use in different countries. This state of knowledge, from the scientific viewpoint, has been summarized elsewhere (Preston, 1977a); the aim of this article is to describe the application of sugar cane feeding in a number of different countries, where emphasis necessarily had to be on development rather than on research.

Developments since 1973

Following the "comfith" conference in 1973 (CIDA, 1973) there were two immediate developments which proved to have fundamental effects on the overall strategy of sugar cane feeding. First, the Government of Quintana Roo, in the least developed part of tropical Mexico, imported the prototype C₄ cane separator from Barbados and set up a large-scale trial comparing the derinded cane with chopped whole sugar cane processed through a rudimentary high-speed forage chopper built in the local government workshops. Second, on the other side of the globe, on Mauritius and in the Seychelles FAO/UNDP-assisted projects were approved to evaluate the new sugar cane separation technology as a basis for beef and milk production; this was under conditions where there was considerable pressure on land and where therefore there was need for maximum productivity per unit area, using cattle under confinement.

In each case the separator (derinder) machines were flown from their point of manufacture to the project site, such was the urgency to initiate the trials. Regarded by many as a profligate waste of money, it was finally justified by the dramatic turn-round in the direction of the whole programme; only four months later (May 1974) the much heralded, sophisticated and expensive "separation" technology was

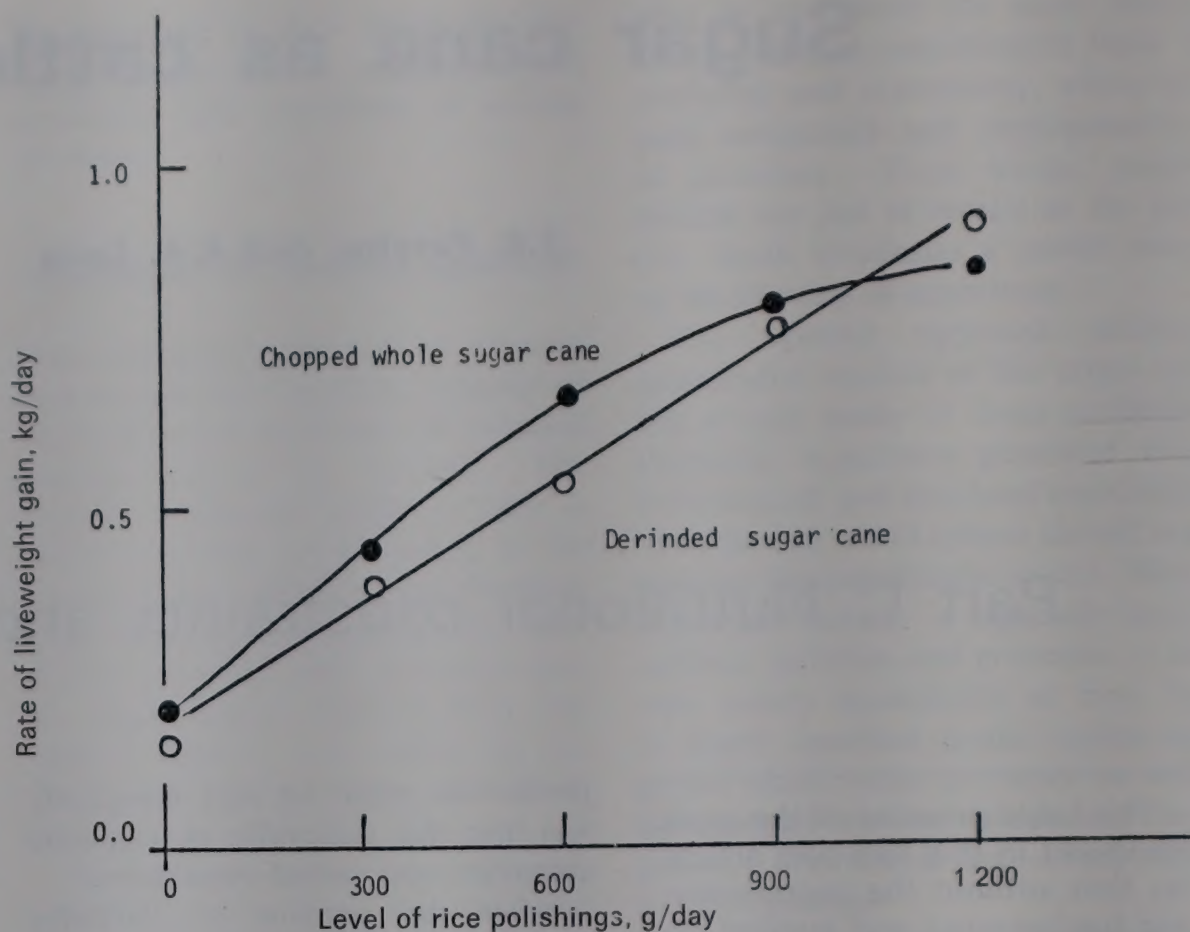


Figure 1 Effect on liveweight gain of level of rice polishings given as a supplement to a basal diet of chopped whole or derinded sugar cane (source: Preston *et al.*, 1976a).

discarded in favour of simple chopping with machines costing less than one twentieth of the price.

The decisive contribution was from the Mexican project (Preston *et al.*, 1976a), where a 400-head feeding trial showed no significant difference in animal performance between derinded and chopped whole cane (in fact, there was an indication of poorer performance with the derinded cane); and that the important factor was not the method of processing but the extent of supplementation (see Figure 1). The findings were confirmed in Mauritius (Preston, 1976), where technical problems resulted in the derinder working only spasmodically and being superseded by a simple whole cane chopper; there was no patent on the Mexican machine, and prototypes had been constructed in Mauritius while the Mexican experiment was still in progress. In the Seychelles, the derinder never emerged from its packing case; local construction of cane choppers obviously merited greater priority in view of their application to small farmer schemes, especially relevant in a country where more than 2 ha of cultivable land in any one site is exceptional.

The almost linear response to supplementation (Figure 1) led to the conclusion that, as with molasses (Preston, 1972), the critical nutrient was dietary protein which would escape rumen degradation (termed "by-pass" protein by Kempton, Nolan and Leng, 1977) to supplement the microbial protein synthesized from the urea in the feed.

It was therefore expected that the feeding technology developed from the considerable research carried out on molasses feeding could be applied to the compounding of supplements for use with sugar cane. Unfortunately this was not to be so. A large-scale commercially oriented trial in Brazil failed completely, with liveweight loss instead of gain (Preston and Bonaspetti, 1974), despite high-level use of a proven "by-pass" protein in the form of meat meal. Events in Mexico also took a backward step as the rainy season superseded the dry; animal performance on the same basal ration fell from 850 g/d to little over maintenance. There were other failures, both at the experimental level and commercially (Preston, T.R., unpublished data).

The wet season problem was undoubtedly complex because nutritional

effects were confounded by management difficulties in getting the sugar cane to the feedlot, in the breakdown of forage choppers which lacked both capacity and robustness, not to mention the accumulation of mud and manure in the pens which caused discomfort to the cattle and made cleaning expensive. Forays were made into ensiling with the idea of providing feed in difficult periods, but, although success was achieved on a laboratory scale (Alvarez and Preston, 1976a; Preston, Hinojosa and Martinez, 1976b), its commercial application under developing country conditions raised new difficulties likely to require more investment and management expertise.

Need for basic research

The need for basic research became evident in order to understand the variable results in the animal feeding trials; the resulting knowledge should, in turn, allow rational manipulation of sugar cane diets for increased production.

Priority was given to digestion and metabolism trials, aimed at throwing light on the nature of the digestion end products of sugar cane feeding, and the relationship of these to the methods of supplementation which had proved effective in practice. Final recourse was made to the use of radioisotopes for monitoring more precisely the key aspects of metabolism.

The final outcome (Leng and Preston, 1976; Preston, 1977a) has been a better understanding of why the results from sugar cane feeding can be so variable; and, more importantly, guidelines have been developed of a philosophy of feeding under tropical conditions which may have a bearing even in temperate countries, e.g., when ruminants are forced to depend more on poorer quality forages and agro-industrial by-products (Preston, 1977b,c).

It is now abundantly clear that the efficient use of sugar cane in cattle feeding depends: first, on understanding the nutritional requirements of ruminants which have to depend on rumen function for the majority of their nutrients for productive purposes; second, on recognizing the factors which affect the feeding value of sugar cane, in terms of meeting these requirements; and third, on providing the most appropriate supplementation (this generally means the cheapest) required to meet the production targets set.

Nutritional requirements of ruminants fed low protein-high sugar diets

Apart from vitamins and minerals, which are easily supplied, the essential components of a suitable feed designated specifically for ruminants (which, *ipso facto*, is not suitable for non-ruminants) appear to be:

- Long fibre for maintenance of efficient rumen function
- Fermentable carbohydrate
- Fermentable nitrogen
- Digestible by-pass protein
- Digestible by-pass glucose precursors.

In addition the feed must give rise to a microbial ecosystem in the rumen with a high and efficient output of microbial and energy-yielding nutrients for the animal.

Long fibre in a ruminant's diet appears to be essential in order to maintain efficient rumen function. It appears to function by providing bulk in the rumen which stimulates development of rumen papillae, but in addition may assist in promoting salivary flow (thus buffering the system and maintaining a high and constant outflow of fluid from the rumen) and provide a suitable environment for an efficient microbial community.

The fermentable energy content of most feeds can be equated with their digestibility, which is directly related to the proportion of cell contents as opposed to cell wall material. If one really aims to utilize the true biological attributes of the ruminant, fermentable nitrogen should be of non-protein origin, and therefore in most cases of inorganic origin, to be added to the diet according to the requirements for an efficient fermentation.

A little too much fermentable nitrogen is less serious than too little, since the ruminant has a fairly wide tolerance of ammonia; and ammonia toxicity only occurs at very high levels of rumen ammonia (Lewis, Hill and Annison, 1957). Any excess ammonia in the rumen is absorbed and then excreted in the urine as urea, which can be recovered as organic fertilizer if there is efficient recycling of animal waste.

Digestible by-pass protein means true protein of dietary origin which, because of its chemical nature or treatment or association (as for example when tannins are present), is not (or is only partially) degraded by the micro-organisms in the rumen, and passes through more or less in intact form, to be digested in and absorbed

Sugar cane separator in Chetumal, Mexico



from the small intestine. Obviously, a good by-pass protein should have an amino acid spectrum which complements that of microbial protein; and which, in practice, means that it should parallel as closely as possible the amino acid composition of milk and tissue proteins. Ways of ensuring that a given protein will "by-pass" the rumen include heat treatment, mixing with sources of tannins, and chemical or physical protection (e.g., reacting with formaldehyde: Ferguson, 1975).

The role of glucose precursors as determinants of productive rate in ruminants is a new concept, first introduced by Leng and Preston (1976), and may be more relevant to sugar-cane than to starch-based diets although similar deficiencies in other related feeds are also suspected (Leng, R.A. and Preston, T.R. — unpublished data). The idea springs from the finding that high biological value by-pass protein alone was not sufficient to elicit acceptable levels of performance (more than 300 g/d liveweight gain) on sugar cane/urea diets (Preston and Bonaspetti, 1974; Silvestre, MacLeod and Preston, 1977a, b), whereas dietary starch alone or in association with protein (Silvestre, MacLeod and Preston, 1976) has always been more effective.

Recent studies using isotope dilution procedures showed that glucose availability to cattle on sugar cane varies directly with intake of rice polishings that contain 12 percent protein, 50 percent starch and 12 percent lipids. The pattern of change of glucose availability indicated that this glucose was possibly coming directly from absorption (Ferreiro *et al.*, 1978a). This has now been confirmed using animals with cannulae in the duodenum. Measurements of starch in duodenal digesta indicated almost quantitative by-pass of the starch of rice polishings (Ferreiro *et al.*, 1978b) which, because glucose entry rates were increased, was apparently digested in the intestines and absorbed as glucose.

Glucose is essential for the ruminant animal since a number of parts of the body depend directly on a source of glucose for their oxidative metabolism (e.g., the brain, red blood cells and kidney medulla); however, in addition



Whole cane chopper in Chetumal, Mexico

there appears to be a considerable need for glucose to supply carbon for tissue synthesis. Thus, recent isotope dilution studies indicated that approximately 10 g of glucose carbon were used in 100 g of body growth in sheep (Leng *et al.*, 1978). These large requirements have to be met by synthesis from short chain precursors because in ruminants in general, and in particular in those on sugar cane diets, little or no glucose is absorbed. In addition, it has been demonstrated recently that there is a linear relationship between glucose synthesized in ruminants and their growth rate (Smith, Kempton and Leng, 1978). In cattle on molasses-based diets, every 100 g of additional growth apparently required 115 g of glucose to be synthesized. In one study the effect of giving glucose post-ruminally by continuous infusion to lambs on a high sugar-low protein diet was to increase the efficiency with which the feed was apparently utilized (Economedes, Ball and Leng, 1978); this suggested that glucose *per se* may spare other essential nutrients (e.g., amino acids) from catabolism or enhance anabolic processes, perhaps through changes in hormonal relationships.

The fact that, in situations where there have been responses to dietary starch, there were no commensurate changes in the ratios of fermentation end products (Silvestre, MacLeod and Preston, 1976, 1977a, b; Minor *et al.*, 1977) or any other parameter (Valdez *et al.*, 1977) suggests that rumen pro-

cesses alone may not be able to produce the amounts of glucose required (via propionate), even if it were possible to manipulate the fermentation. Direct feeding of propionic acid was also ineffective (Ferreiro, Preston and Sutherland, 1977). The apparently limited (and occasionally complete lack of) response to by-pass protein when not accompanied by starch (e.g., in protein meals of animal origin) indicates that the synthesis of glucose from de-aminated amino acids is not an important pathway in quantitative terms.

Fermentable nitrogen, by-pass protein and glucose or glucose precursors all function as rate limiting nutrients; each one at times may be the rate limiting factor. The amounts of these that should be added to a sugar cane diet will be governed by economic rather than nutritional considerations. In practice, fermentable nitrogen can almost always be included in nutritionally optimum amounts as it is cheap, and what is not utilized by the animal can be recycled and used as fertilizer.

By-pass starch and protein are almost always expensive when they originate from cereals and oilseeds (oilseed cake usually contains about 10 percent starch) and animal by-products; hence they generally have to be used at levels less than are required to maximize animal performance. Future trends here will be to find methods to ensure more efficient "protection" and therefore "by-pass" proper-

ties, or to provide such supplements from specific cropping systems.

Nutritional constraints governing use of sugar cane

These have been discussed in detail by Leng and Preston (1976) and Preston (1977a) and can be summarized as follows:

- Nutritive value (both digestibility and efficiency of utilization of digested energy) increases with maturity and for all practical purposes can be linearly related to the sugar content of the juice (Brix value).
- Fineness of chopping of whole sugar cane within a range of particle sizes of 3 to 30 mm (approximately) does not appear to affect either digestibility or voluntary intake. Removing the rind from the cane stalk (to produce the comfith of the Barbados project) raises digestibility (by about 15 percent) but decreases voluntary intake, so that the final overall effect on animal performance is nearer 10 percent (Table 1). The more lignified rind may become a constraint if the aim is to achieve high levels of animal performance, but this is not economically feasible at present, owing to the high costs of conventional feed supplements which are required to support such performance rates.
- Irrespective of the method of processing of the sugar cane stalk, there

will be an improvement in voluntary intake when forage which contains long fibres is also given (e.g., the sugar cane leaves). Such forage should not be chopped or ground too finely because its stimulating function on rumen turnover rate will be reduced.

- From theoretical considerations (confirmed by practical feeding trials), the level of urea needed to cover the requirements for fermentable nitrogen (as urea) can be estimated from the formula:

$$\text{g urea/kg fresh cane} = 0.6 \text{ Brix} (94.8-1.12)/(100-\text{Brix}).$$

- The method of incorporating the urea in the diet is not critical; it can be given as an aqueous solution added to the cane at the time of chopping or mixed in afterwards, or as a concentrated solution in molasses (e.g., 10 percent) fed *ad libitum* in a separate feeder.
- It is probably advisable in most situations to give additional sulphur (for rumen micro-organisms); this can be most efficiently accomplished by providing one tenth of the inorganic nitrogen supply in the form of ammonium sulphate.
- Sugar cane, even when supplemented with urea and sulphur, will only support maintenance but is nevertheless useful in this role as a drought and emergency feed. Low-to-moderate growth rates (e.g., up to 400 g/d liveweight gain) require at least by-pass glucose precursors (by-

pass protein alone is less effective), probably given most efficiently as finely ground, starch-containing cereal by-products (or dried tropical roots) or fresh green bananas. However, the degradability in the rumen of any potential by-pass starch should be estimated. Addition of by-pass protein as well as glucose precursors will be needed for moderate-to-high rates of animal performance, particularly milk production.

- Suckled milk is almost certainly the most efficient and probably the most economical source of by-pass glucose precursors and protein for the young, growing ruminant, and management systems for calf rearing on sugar cane-based diets will be more efficient if they incorporate late weaning or restricted suckling procedures.
- It is axiomatic that mineral supplementation should be provided for sugar cane, particularly phosphorus and sodium and, among the trace elements, cobalt. Vitamin supplementation is probably unnecessary, assuming that the housing system allows some direct sunlight to enter.

Microbiological constraints on the use of sugar cane

Recent studies on the role of protozoa in rumen function of cattle given sugar cane-based diets indicated that protozoa were often present in large numbers representing a very large biomass (Valdez *et al.*, 1977). The pattern of change of protozoal numbers in samples taken from the centre of the rumen suggested a cyclical activity and apparent settling out of the protozoa. Studies in slaughtered animals indicated a lack of movement of these protozoa out of the rumen (Minor *et al.*, 1977) confirming results obtained with sheep (Weller and Pilgrim, 1974; Bird *et al.*, 1978). This brings up the question of their role in rumen fermentation. Recent studies by Bird and Leng (1978) with defaunated cattle on a low protein molasses-based diet (which also supports large populations of rumen protozoa) indicated a significant increase in animal productivity in defaunated ani-

TABLE 1. Comparison of chopped whole or derinded sugar cane as the energy source for cattle

Liveweight gain (g/d)		Change due to derinding (%)	Source
Chopped whole stalk	Derinded stalk		
728	568	-28	Montpellier, Valdez & Preston (1977)
650	600	-8	Preston <i>et al.</i> (1976a)
620	610	-2	Yousef (1978)
940	940	0	James (1978)
850	930	9	Preston <i>et al.</i> (1976a)
930	1 020	10	James (1978)
650	750	15	Yousef (1978)
520	620	17	Gonzalez & Williams (1976)

mals compared to animals which were not treated. The rate of growth was increased by 43 percent, and efficiency of utilization of feed by 39 percent.

These findings, if applicable to sugar cane diets, may result in big increases in productivity, or conversely a decrease in the requirements for by-pass nutrients (which are the economically limiting components of sugar cane-based diets) provided suitable means (i.e., for application in developing countries in the tropics) of removing the protozoa can be found. This is an area of research currently being pursued. ■

References

- ALVAREZ, F.J. & PRESTON, T.R. 1976a. Ammonia/molasses and urea/molasses as additives for ensiled sugar cane. *Trop. Anim. Prod.*, 1: 98-104.
- BIRD, S. & LENG, R.A. 1978. The effect of defaunation of the rumen on the growth of cattle on low protein high energy diets. *Brit. J. Nutr.* (In press)
- BIRD, S., BAIGENT, D.R., DIXON, R. & LENG, R.A. 1978. Ruminant protozoa and growth of lambs. *Proc. Austral. Soc. Anim. Prod.*, 22: 137.
- CIDA. 1973. Sugar cane as livestock feed. *Proceedings of the CIDA Seminar, Barbados, 30-31 January 1973.*
- ECONOMEDES, S., BALL, F.N. & LENG, R.A. 1978. *The effects of glucose infused post ruminally on growth and efficiency of conversion of feed of lambs on low protein high energy diets.* To be submitted to *Brit. J. Nutr.*
- FERGUSON, K.A. 1975. In *Digestion and metabolism in the ruminant*. Armidale, N.S.W. University of New England.
- FERREIRO, H.M., PRESTON, T.R. & SUTHERLAND, T.M. 1977. Investigation of dietary limitations on sugar cane based diets. *Trop. Anim. Prod.*, 2: 56-61.
- FERREIRO, H.M., PRIEGO, A., LÓPEZ, J., PRESTON, T.R. & LENG, R.A. 1978a. *Glucose metabolism in cattle given sugar cane based diets supplemented with varying quantities of rice polishings.* Submitted to *Brit. J. Nutr.*
- FERREIRO, H.M., ELLIOTT, R., PRIEGO, A. & PRESTON, T.R. 1978b. Passage of starch through the duodenum in cattle fed sugar cane and rice polishings. *Trop. Anim. Prod.*, 3. (In press)
- GONZALEZ, I. & WILLIAMS, A. 1976. Preliminary investigations on derinded sugar cane as cattle feed. *Trop. Anim. Prod.*, 1: 227, Abs.
- JAMES, L. 1978. Derinded and chopped whole sugar cane for fattening cattle. *Proc. Symposium at Sugar Cane Feeds Centre, Trinidad, UWI, February 1978.*
- KEMPTON, T.J., NOLAN, J.V. & LENG, R.A. 1977. Principles for the use of non-protein nitrogen and by-pass proteins in ruminants. *Wld Anim. Rev. (FAO)*, 22: 2-10.
- LENG, R.A. & PRESTON, T.R. 1976. Sugar cane for cattle production: present constraints, perspectives and research priorities. *Trop. Anim. Prod.*, 1: 1-22.
- LENG, R.A., STACHIW, S., BALL, F.N. & NOLAN, J.V. 1978. *The role of glucose carbon in body growth.* To be submitted to *Brit. J. Nutr.*
- LEWIS, D., HILL, K.J. & ANNISON, E.F. 1957. Studies on the portal blood of sheep. 1 - Absorption of ammonia from the rumen of the sheep. *Biochem. J.*, 60: 587.
- MINOR, S., MACLEOD, N.A., PRESTON, T.R. & LENG, R.A. 1977. Studies on digestion in different sections of the intestinal tract of bulls fed sugar cane/urea with different supplements. *Trop. Anim. Prod.*, 2: 163-174.
- MONTPELLIER, F.A., VALDEZ, R.E. & PRESTON, T.R. 1977. Processing of sugar cane: effect of derinding and coarseness of chopping on animal performance and rumen fermentation. *Trop. Anim. Prod.*, 2: 206-212.
- PRESTON, T.R. 1972. Molasses as a feed for cattle. Ed. G.H. Bourne. *Wld. Rev. Nutr. Diet.* Basle, Karger.
- PRESTON, T.R. 1976. *Milk and beef from sugar cane.* Report to Ministry of Agriculture, Mauritius. (FAO/UNDP MAR/75/004).
- PRESTON, T.R. 1977a. Nutritive value of sugar cane for ruminants. *Trop. Anim. Prod.*, 2: 125-142.
- PRESTON, T.R. 1977b. A strategy for cattle production in the tropics. *Wld Anim. Rev. (FAO)*, 21: 11-17.
- PRESTON, T.R. 1977c. Utilization of agro-industrial by-products in integrated systems of plant and animal production. *FAO Consultation on New Feed Resources.* Rome, FAO.
- PRESTON, T.R. & BONASPETTI, E. 1974. El uso de harina de carne y úrea como suplementos en una ración de engorde de caña de azúcar integral picada. *Reunión Anual del CIEG, Informe Anual 1974 CIEG, Chetumal, Mexico.*
- PRESTON, T.R., CARCAÑO, C., ALVAREZ, F.J. & GUTIERREZ, D.G. 1976a. Rice polishings as a supplement in a sugar cane diet: effect of level of rice polishings and of processing the sugar cane by derinding or chopping. *Trop. Anim. Prod.*, 1: 150-161.
- PRESTON, T.R., HINOJOSA, C.P. & MARTINEZ, L. 1976b. Ensiling of sugar cane with ammonia, molasses and mineral acids. *Trop. Anim. Prod.*, 1: 120-127.
- SILVESTRE, R., MACLEOD, N.A. & PRESTON, T.R. 1976. Supplementation of sugar cane/urea diets for growing cattle: different levels of maize grain and protein concentrate. *Trop. Anim. Prod.*, 1: 206-214.
- SILVESTRE, R., MACLEOD, N.A. & PRESTON, T.R. 1977a. Supplementation of sugar cane/urea for growing cattle: effect of maize grain and different levels and sources of protein. *Trop. Anim. Prod.*, 2: 81-89.
- SILVESTRE, R., MACLEOD, N.A. & PRESTON, T.R. 1977b. Effect of meat meal, dried cassava root and groundnut oil in diets based on sugar cane/urea or molasses/urea. *Trop. Anim. Prod.*, 2: 151-157.
- SMITH, G.H., KEMPTON, T.J. & LENG, R.A. 1978. *Glucose metabolism and growth in cattle.* To be submitted to *Brit. J. Nutr.*
- VALDEZ, R.E., ALVAREZ, F.J., FERREIRO, H.M., GUERRA, F., LOPEZ, J., PRIEGO, A., BLACKBURN, T.H., LENG, R.A. & PRESTON, T.R. 1977. Rumen function in cattle given sugar cane. *Trop. Anim. Prod.*, 2: 260-272.
- WELLER, R.A. & PILGRIM, A.F. 1974. Passage of protozoa and volatile fatty acids from the rumen of the sheep and from a continuous *in vitro* fermentation system. *Br. J. Nutr.*, 32: 341.
- YOUSEF, J. 1978. Studies on feeding sugar cane to cattle. *Proc. Symposium at Sugar Cane Feeds Centre, Trinidad, UWI, February 1978.*

Sheep in Sri Lanka

V. Buvanendran

This account of the sheep in Sri Lanka was commissioned as part of an FAO/UNEP project on the "Conservation of Animal Genetic Resources". It demonstrates the difficulty of keeping temperate woolled sheep in a humid tropical environment. If improvement of hair sheep in such an environment is desired, first consideration should be given to using hair sheep from a similar tropical climate. It is interesting to contrast the situation in Java where the climate is similar but where there is a large population of prolific woolled sheep. An article on sheep in Java follows this one on sheep in Sri Lanka.

The Editor

Sheep are at present not important to the national economy of Sri Lanka. The official census of 1962 recorded 25 000 indigenous sheep, mostly in the northern and eastern regions of the island, but numbers have declined considerably since then. Present estimates are that the number is close to 15 000. Exotic breeds have been introduced during the last decade to improve the indigenous sheep, the major importations being from south India. Smaller numbers of European breeds were also imported, the important ones being Wiltshire Horn from the U.K. and Poll Dorset and Southdown from Australia.

Jaffna sheep. The indigenous sheep are probably derived from south India. They are confined to the northern and eastern parts of the island, but the greatest concentration is in a relatively small area around Jaffna in the north. The indigenous breed is therefore referred to as Jaffna sheep. It is hairy and has no wool; the hair is longer on the back of the thighs. The sheep are of mixed colour — pure black, pure tan, black and white, tan and

white, and white with occasional coloured patches — and most flocks contain a mixture of all of these colours. Females are polled, while the males may be either horned or polled; polled rams are preferred for breeding purposes to minimize fighting and butting among animals. The tail is extremely short. External ears may be rudimentary, short or of normal size. Shepherds prefer animals with rudimentary ears as they believe that these animals have a keen sense of hearing and are thus better able to protect themselves from predators, chiefly stray dogs.

The Jaffna sheep is small, the weights of adult males and females being 23 kg and 18 kg respectively. Weights of younger female sheep recorded from three flocks with about 250 sheep were as follows: 10-12 months, 13.6 kg; and 2-3 years 15.5 kg.

Ewes lamb only once a year but will breed at any time of the year. Though some flocks have their peak lambing during July-August, maximum lambing occurs in December-January, the preferred season after the heavy November-December monsoonal rains, when availability of feed is greatest (however, the highest mortality due to exposure is found among lambs born during these rains). Mortality among lambs varies from 10 to 20 percent, the chief causes being inflammation of

the sinuses and pneumonia. Some shepherds practise hot-iron branding of the lambs in the area between the eyes as a treatment for inflammation of the sinuses.

The average age at first lambing is about 18 months. Twinning is virtually non-existent. Lambing percentages are about 80 percent, but the average number of lambs reared to one year of age is about 65 percent. The others are lost through exposure, predators and starvation during the drought period of February-April or July-September.

The animals are hardy and rarely suffer from parasitic infestations. However, flock owners complain about outbreaks of an epidemic disease (the last one being about three years ago), with symptoms similar to anthrax (sudden deaths with bloody discharges from the orifices), that takes a heavy toll, resulting in mortalities of 60-90 percent.

Average flock size is about 100 sheep, consisting approximately of 65-70 ewes, 20-25 ewe lambs, 2 rams and a few unsold ram lambs. Flocks are generally closed, and there is hardly any movement of animals between flocks. The small size of the units and the practice of closed breeding inevitably results in considerable inbreeding within flocks.

Sheep are kept primarily for the production of manure. Flocks are grazed and herded during the day on paddy stubble after harvest and on common grazing land. At night they are penned in branch-and-stick enclosures on arable lands used for onion, chilli or paddy crops, and by their dung and urine they fertilize the land. Shepherds are paid by the crop farmers at the rate of Rs. 0.10 (U.S. \$1.00 = 16 Sri Lankan rupees) for

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each sheep penned per night on their lands. The major share of income from sheep is thus derived by hiring them for manure. Income from this source, however, is limited to only six months of the year, as it is only during the period between harvesting and the following planting season that animals are penned for manure. At other times flock owners collect the manure in pens or sheds constructed in their own yards for sale to crop

farmers. Sheep dung is believed to release the nitrogen almost immediately after application and is therefore claimed to be superior to cattle dung.

The other source of income is from the sale of ram lambs and old ewes to butchers. Ram lambs are sold when they are about 9-12 months of age for about Rs. 90 per animal. Owing to the attractive prices paid for sheep consequent on the scarcity of beef, flock owners have shown interest in

receiving rams of improved breeds to increase growth rates of their sheep. A scheme is in operation whereby farmers are given rams of Indian breeds such as Bannur or Red Madras by the National Livestock Development Board. In return, the farmer gives one or two animals of equal weight to the Board for slaughter.

Indian breeds. About 1 000 of the coarse-woolled Bikaneri sheep were

Red Madras and Jaffna females at Bingiriya, Sri Lanka. (Credit: I.L. Mason)



imported from Rajasthan in 1968 to the Wirawila Government Farm in the southern dry zone. Many were lost because the wool was not shorn and did not shed, and in wet conditions the animals developed pneumonia; nasal bot fly (*Oestrus ovis*) and mange infections were also additional factors in the initial loss of animals. However, better management and shearing have minimized the mortality, although mange still continues to be a problem. In order to improve the meat potential of this breed, crossing with the Wiltshire and Dorset was attempted, but most of the rams either died or became infertile in the hot, humid climate of this region. Half-bred or threequarter-bred Wiltshire and Dorset rams (based on Jaffna ewes) bred at Bopatalawa Farm in the hill country have been brought to Wirawila and crossed with the Bikaneri with the intention of forming a new breed with 25 percent blood of each of the four breeds: Dorset, Wiltshire, Bikaneri and Jaffna. Lambing percentages of the crossbreds have averaged over 90 percent, and mortality to weaning has been 5-8 percent. Weights of some of the crossbred ewe lambs are given in Table 1.

TABLE 1. Weights of some crossbred ewe lambs (kg)

Sire	Dam	Kg	
		3 months	6 months
DL	B	14.0	18.6
WL	B	14.5	19.3
WL	(WL × B)	15.8	21.2

(DL = Dorset × Jaffna; WL = Wiltshire × Jaffna; B = Bikaneri.)

Crossbred ewes (WL × B) have more milk than the Bikaneri, which has helped to increase weaning weights and reduce lamb mortality.

The management system practised is to graze the animals on *Brachiaria mutica* pastures during the day and to house them at night in open sheds. Concentrates consisting of coconut cake and rice bran with minerals are given at 0.11 kg/animal/day during flushing, and to ewes during the latter part of pregnancy and during the first

two months after lambing. Topping is restricted to the period from mid-July till end August, and ewes lamb during late December and January.

There have been several importations of south Indian sheep by coconut-estate owners during 1970-72 consisting of Mecheri, Red Madras, Bannur and Nellore breeds. In 1975, 330 Red Madras and 834 Bannur sheep were imported by the Indo-Sri Lanka Sheep Development Project to the National Livestock Development Board Farm at Bingiriya in the coconut triangle; 260 Jaffna ewes were also obtained. Many of the Indian sheep were distributed to farmers; by September 1977, total numbers had increased to 346 Red Madras and 1 100 Bannur.

The sheep graze *Brachiaria mili-formis* pasture under coconuts from 09.00 to 18.00 hours on a rotational system. Ewes are first mated at 12-14 months. All three breeds will breed throughout the year, but lambing is now restricted to two periods: October-November, and April-May. Ewes lamb only once a year, twins are non-existent, but conception rate is 96 percent. However, abortions and lamb mortality reduce the weaning rate to 55 percent, part of this mortality being due to the ewes having insufficient milk — especially the Bannur.

The chief disease problem is parasites: nematodes (especially *Haemonchus*), bot fly (*Oestrus ovis*), and tapeworms. Lambs have to be drenched against worms every month. There is no enterotoxaemia or anthrax. The Jaffna breed is the most resistant to parasites and the Bannur the least.

In body weight the breeds come in reverse order as seen in Table 2.

TABLE 2. Body weights according to breed

Breed	Adult females	Adult males
	Kg	
Bannur	25	30
Red Madras	24	27
Jaffna	18	

European breeds. Seventy-one Wiltshire Horn ewes and seven rams were imported from England in 1965 and 34 Poll Dorset ewes and six rams were received from Australia as a gift in 1968. These were kept at Bopatalawa Farm at 1 524 m in the high wet lands, but the Poll Dorsets have since been moved to Boralanda Farm in the dry patanas; their performance is described by Buvanendran *et al.* (1970)¹. To date, the overall reproductive performance in the Wiltshire Horns was only 0.39 lambs per ewe mated per year, while in the Poll Dorsets it was 0.65. The causes of this low reproductive rate were high age at first lambing, barrenness, low litter size, high lamb mortality to weaning, and long intervals between lambs. The imported breeds have distinct lambing seasons, the Wiltshire from December to February and the Dorsets from December to January and March to June.

These two breeds have been crossed with the Jaffna ewe in crossbreeding experiments and some of the weights obtained with crossbred lambs are shown in Table 3. The F₁ lambs of

TABLE 3. Growth and mortality rate of some crossbred lambs

Sire	Dam	Weaning (3 months)	6 months	1 year	Mortality to weaning
		Kg			Percent
W	L	11.0	20.9	28.8	0
D	L	14.1	20.5	28.3	0
W	W	14.1	19.5	29.5	12.5
D	WL	18.6	25.3	32.7	6.0
W	WL	15.0	21.0	27.6	5.0

(W = Wiltshire; D = Dorset; L = Jaffna; WL = Wiltshire × Jaffna F₁; DL = Dorset × Jaffna F₁.)



A flock of Bannur females. (Credit: I.L. Mason)

Dorset or Wiltshire with Jaffna ewes showed the same growth rate as the pure Wiltshire. However, lambs sired by Dorset on WL ewes (F_1) were superior in growth rate to Wiltshire $\times$ WL lambs. Mortality among lambs was highest in purebred Wiltshire.

In 1971 most of the Wiltshire Horns died following mouth lesions similar to foot-and-mouth disease. The cross-breeds with Jaffna sheep were only mildly affected, and there were no losses.

Another Australian gift of about 50 Southdown sheep was received in 1971. These were kept at the Boralanda Sheep Research Station located in the dry patana region (1 219.

1 524 m). Though this breed has been unsuccessful in the intermediate wet zone areas under coconut because of high mortality and poor reproductive rate, they have multiplied and grown in a satisfactory manner at Boralanda. Recently, a liver disease which appears to be a photosensitivity disease (like facial eczema) has caused considerable mortality (20-30 percent) in Southdown and Poll Dorset lambs after weaning. Keeping lambs out of the sun has not prevented this affliction.

Summary

The indigenous sheep of Sri Lanka, the Jaffna sheep, are small in size

and are kept mainly for the production of manure and to a lesser extent as a source of income from the sale of ram lambs and old ewes to butchers. Attempts have been made to improve the productivity of the Jaffna sheep by crossing them with imported Indian (Bannur, Bikaneri and Red Madras) and European (Wiltshire Horn and Polled Dorset) breeds. The results of these attempts are summarized in this article. ■

¹ Buvanendran, V., Jainudeen, S.R.M., Jayasekera, S.B. and Dharmasiri, G.A. 1970. Performance of two temperate breeds of sheep in Ceylon. *Ceylon Vet. J.*, XVIII (3): 70-75.

Sheep in Java

I.L. Mason

According to the FAO Production Yearbook for 1976, 95 percent of the sheep in southeast Asia are located in Indonesia. None are recorded in Brunei, Lao, Sabah, Sarawak or Singapore; Democratic Kampuchea has 2 000, Viet Nam 12 000, the Philippines 32 000, Peninsular Malaysia 46 000 and Thailand 54 000, making a total of 146 000. Indonesia on the other hand has 3 188 000. Numbers declined slowly in the years preceding 1972-74, but have since stabilized.

Within Indonesia the distribution is equally irregular as shown in the following table. Ninety percent of the sheep are on the island of Java, and within Java itself their density is three times as great in the west (the wetter end) as in the east. Goats are more numerous than sheep in all provinces except West Java, where sheep outnumber goats in the ratio three to two.

This concentration of sheep in one of the most densely populated islands in the world, and in a climate defined as humid tropical, is clearly worth study, the results of which should be of interest also to other countries in the region. It should also be noted that these sheep have a reputation for high fertility: Groenewold (1971) gives a total lamb production of 200-220

lambs per 100 mature ewes per year. The Javanese sheep clearly merited inclusion in the FAO/UNEP study of prolific and tropical sheep.

Sheep husbandry

Sheep are the next most important source of meat for the rural population after poultry and goats (except in West Java). They are also valued as a source of manure and as a form of saving (this last point makes numbers more important than size). Wool production is relatively unimportant, and ewes are never milked.

Sheep ownership averages about 3-5 animals per farmer. The animals graze waste land during the day and are kept at night in simple covered bamboo pens or sheds; these have slatted or woven bamboo floors raised 30-40 cm off the ground. There they are fed on cut forage and agricultural

wastes; sometimes they are given rice bran and salt.

Disease does not appear to be a problem. No trouble from foot rot was reported. In West Java fluke, tapeworm and *Haemonchus* were named as the most serious afflictions. In Central Java, scab, not *Haemonchus*, is the chief problem. In East Java helminths are the major parasites, and *Haemonchus* may be a cause of mortality. Modern drugs are too expensive for the ordinary farmer to use in the control or treatment of parasites and diseases, but traditional methods may be used, e.g., against fluke. No doubt the slatted floors are an advantage and may account for the absence of foot rot. Rotational grazing would be desirable but is difficult to implement because of the restricted grazing area available.

Breeds

There appear to be three native sheep breeds in Java: the local Javanese thin-tailed; the Priangan of West Java; and the fat-tailed sheep of East Java.

Javanese thin-tailed. This is the common sheep of West and Central Java. It is said to occur also in East Java, but in fact the author saw only fat-tailed sheep there. In West Java it is estimated that 80-85 percent of the sheep belong to the local breed, the rest being Priangan. It is a small sheep, with an average slaughter

Sheep distribution in Indonesia, 1973

West Java (including Djakarta)	1 450 000
Central Java (including Jogjakarta)	928 000
East Java (including Madura)	475 000
Sumatra	207 000
Other islands	147 000
	3 207 000

Source: Buku Saku Peternakan, Direktorat Penyuluhan, Peternakan, Djakarta, 1975.

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weight of only 19 kg according to the official figure of the Ministry of Agriculture (Buku Saku Peternakan, 1975) but a wither height of 57 cm. Adi Sudono (1965) gives weights of 20-35 kg for adult females and 35-60 kg for adult males.

It is usually white and commonly has black patches around the eyes and nose and occasionally elsewhere. The tail shows no sign of fat and does not reach the hocks. The ram carries closely curled horns, and the ewe is normally polled. The ears are of medium size and are carried in a semi-pendulous position.

This breed is not mentioned by Fischer (1955) nor by Robinson (1977), although it is the dominant breed of Indonesia. The local sheep at P4 (Pusat Penelitian dan Pengembangan Peternakan — The Australian/Indonesian Centre for Animal Research and Development), Bogor, which are called Priangan might be more appropriately termed Javanese thin-tailed.

Priangan. In the Priangan region of West Java which includes the districts of Bandung and Garut, there is a breed of sheep which has been developed primarily for ram fighting. It differs from the common thin-tailed sheep in its larger size, convex facial profile, high frequency of the earless gene, variety of colour and by the presence of a throat ruff or mane and a distinct deposit of fat at the base of the tail.

Tradition has it that this breed was created in 1864 by Adipati Limbangan in the Garut district by crossing Merino and Cape (presumably Afrikander) sheep from South Africa on to the local sheep. The author has seen no documentary evidence concerning this importation or the subsequent crossbreeding, nor do Merino characteristics appear obvious in the Priangan. However, it is possible that the slight fat on the tail and the throat ruff were contributed by the Afrikander, which is a hairy fat-tailed breed.

The colour is extremely varied. The 66 rams which the author saw at the ram-fighting competition in Bandung on 14 August 1977 were roughly categorized as follows:

Black	12
Black with little white (on tail, feet, poll)	6
Black-and-white pied	26
White with little black (on face, feet, rump)	10
White	1
Grey or grey-and-white	7
Tan or tan-and-white	4

The horns of the male (females are polled) are heavy with pronounced

Some authorities (including Robinson, 1977) distinguish between the Priangan and the Garut, restricting the latter name for the strain used solely for fighting. It is said to have a higher incidence of short or absent ears. This distinction appears to be artificial and unnecessary, and most people use the names Priangan and Garut as synonyms.

Pure Priangans number about 250 000, but the rams are used for



A local Javanese thin-tailed ewe with triplets near Jogjakarta. (Credit: I.L. Mason)

cross ridges and sharp angles. They are usually closely coiled (as in the local sheep or the Merino) but occasionally form a loose lateral spiral (as in the Afrikander). Sometimes the ram has four horns (but the author did not see any such animals) and sometimes the ewe has scurs. The tail rarely extends more than half way to the hocks. The throat ruff is rendered more conspicuous in the fighting rams by shearing the fleece from all the body except the neck and shoulders.

grading up the local sheep; thus it is difficult to make an absolute distinction between Priangan and Javanese thin-tailed.

Opinions differ about the weight of the Priangan. Merkens and Soemirat (1926) gave a weight of 30-40 kg for the females and 60-80 kg for the males. For 1954 BPPP (Balai Pusat Penjelidikan Peternakan) gives an average of 38 kg for females and 58 kg for females. On the other hand, Dr. Atmadilaga considers that the average weight today is only 20-30 kg for

females. Since he describes (1958) one third of the sheep of Indonesia as Priangan (i.e., 1 million rather than 1/4 million), he perhaps uses the name to embrace the local sheep which have been partially graded to Priangan *sensu stricto*.

The West Java Livestock Husbandry Inspectorate has recently started a flock of 200 two-year-old Priangan ewes at Maragawati near Garut. They will be fully recorded and selected

sheep of Iran, Afghanistan and Pakistan. The native Indonesian word for sheep is "biribiri".

In the island of Madura all sheep belong to this breed. They have spread into East Java where now most of the sheep are fat-tailed. The author saw fat-tailed sheep between Surabaya and Situbondo and in the neighbouring village of Semiring, but the tails were smaller than on Madura. On Madura the tail of the first-

Central Java are said to be fat-tailed, but around Jogjakarta the author saw only the local thin-tailed sheep except in the Kaliurang Experiment Station.

The sheep of the eastern islands

Lombok, Sumbawa, Kisar, Sawa — are also fat-tailed. In southern Sulawesi there is a breed called Donggala which Dr. Atmadigala describes as fat-rumped. Fat-tailed sheep from Lombok have recently been imported into Irian Jaya.

The typical fat-tailed sheep is completely white and is hornless in both sexes. Occasionally rams carry scurs or small horns. As in the other breeds ears are normally of medium size and semi-lop, but the earless gene is present. Fat-tailed sheep are larger than the thin-tailed. Buku Saku Peter-nakan (1975) gives an average live-weight at slaughter of 24 kg, compared with 19 kg for the local sheep. In fact "superquality" rams can weigh 45-50 kg and ewes 30 kg. BPPP (1954) gives weights of 43 kg for males and 40 kg for females.

There is no crossbreeding in East Java and Madura, but the Government runs an improvement programme based on selection within the pure breed. Rams selected on size and conformation (the "superquality" rams mentioned above) are bought by the Government and distributed to villages. Here they are kept by one man but are run with the whole village flock of ewes. After 2-3 years the ram becomes the property of the farmer who has looked after it. Ewes are also distributed and are passed on to a different farmer after they have had 1-2 lambs.



Priangan ewe with four lambs at Bandung. (Credit: I.L. Mason)

for meat characters. The aim is to produce improved stock for distribution.

East Java fat-tailed. The sheep of Madura and East Java differ from those of West Java in having a fat tail. They are also, typically, white and hornless.

These sheep are said to have been brought originally from southwest Asia by Arab traders; some specify from Iran. It may be significant that "dumba" is the Persian for "tail" and has been used to refer to the fat-tailed

quality sheep was usually strap-shaped or carrot-shaped and hung to the hocks. A stick may be put through the tail of the ram lamb to bend it up and make it get fatter. In Semiring the tail was much smaller, not reaching to the hocks, and triangular in shape.

Even in Central Java the fat-tailed sheep is preferred because of the better taste of its meat, its superior leather and, above all, its larger size. The tail itself is a culinary delicacy. More than 50 percent of sheep in

Ram competitions

The Priangan sheep are bred primarily for "ram fighting", although this term is misleading. Animals are rarely hurt and the author saw no sign of blood during the encounters.

The competitions are held regularly in Bandung and at smaller local centres. Competing rams are divided into three classes based on age and size and fight in pairs only within their own class. They start at 2 years of age and continue for 4-5 years.

Fighting rams are given a special diet which, in addition to grass and concentrates, may contain eggs, honey, liver or iron tonic, and black beer. They are given intensive training which includes exercise, practice fighting, swimming and massage. The resulting animal is large, muscular, well grown without being fat, and remarkably docile except during the actual combat.

The fight takes place on a grass surface within a circle of spectators. A band plays and the rams are encouraged by the dancing and singing of their attendants. The competitors are placed facing each other and a half metre apart in the centre of the ring. They back away from each other up to a distance of 5-10 metres and then charge each other with their heads down to collide head on. The base of the horn takes the major impact. They then back away and charge again. This may be repeated up to 50 times in the case of the largest class but up to only 25 for the smallest class. After 10-12 encounters there is a pause during which the animals are petted and groomed. If one ram is a clear winner by knocking the other down or forcing him backward or if one is a clear loser by walking away or losing interest, the fight is stopped. Usually the two adversaries are very closely matched and the winner is decided by a group of six judges who award points on the basis of aggressiveness, style, dexterity, alertness and stamina. If there is any gambling on the result, it is not conducted openly.

The rams are selected for size, horn size and for ability. The champion rams are highly prized and may fetch up to 300 000 rupiah¹. However, they are not used for breeding during their careers, as it is feared that mating would deprive them of their competitiveness.

Selection for fighting ability should also improve mutton production by producing a large muscular, healthy animal. It may, however, emphasize development of the forequarters rather than the hindquarters.

¹ U.S.\$1.00 = 415 rupiah (November 1977).

Wool production

All Javanese sheep carry a light fleece of extremely irregular, coarse, hairy wool. Previous descriptions of a hair breed appear to have arisen because of the thinness of the fleece, the frequency of shearing and the shedding of unshorn fleeces. Fleece weight averages only 200-300 g per year from ewes and about twice as much from rams (BPPP 1955). There do not seem to have been sufficient measure-

thrown away. In East Java the fleece may be allowed to shed naturally.

Even in West Java wool is used commercially only to a very small extent, but it may be used as manure. There are three carpet factories, two of which are in Bogor and Bandung. The Java Carpet Factory in Bogor receives about 3 tons of wool per month. The wool is scoured, carded, spun, dyed and made into thick tufted carpets. The factory would like to expand production but cannot get the wool. Possibly the price is too low;



Priangan ram at Ram-fighting Competition at Bandung. (Credit: I.L. Mason)

ments to pinpoint any breed differences in weight and quality of wool, and opinions on this point are contradictory.

At first sight the sheep on Madura appeared woolless, but this is due to the fact that they are shorn every three months. They are also washed regularly (in the sea) and there may be more frequent partial shears to remove any dirty wool. Clean woolless sheep are believed to thrive better than dirty unshorn ones. The wool is

the farmer receives only 80 rupiah per kilogram of greasy wool.

Some wool is exported from East Java to Singapore.

Reproduction

Age at first mating of ewes varies from 6 to 12 months. Lambing may occur at any time of the year. With careful management ewes can lamb every 6 months, but a lambing interval

of 8-9 months is more usual. In Madura the rams may be removed from the flock after the birth of the lambs, so that only one lamb crop per year is obtained.

Fat-tailed ewes are kept for at least three years. At 4 years they may be sold for slaughter on account of barrenness; the old females are difficult to mate because of the fat tail. Hand-mating with human help may be necessary.

Rams are active from 6 months to 5 years of age but are usually slaugh-

karta, and one set of quadruplets with a Priangan ewe at Bandung.

Reviews by Zulfardi (1977) and by Ambar Rusyad (1977) of LPP (Lembaga Penelitian Peternakan — The Animal Husbandry Research Institute), Bogor, quote prolificacies (lambs per 100 ewes lambing) varying from 145 to 213 percent for the Priangan, 156 percent for the fat-tailed, and 104 to 160 percent for the local thin-tailed. There was a small percentage of triplets and an occasional set of quadruplets.

provisional figures for the prolificacy and lambing rate of the three breeds:

	Prolificacy (%)	Lambs per 100 ewes per year
Priangan (mean of 6 figures)	170	255
Fat-tailed (1 figure)	156	234
Local thin-tailed (mean of 7 figures)	136	204

An 8-month lambing interval is assumed, so the lamb production per year is obtained by multiplying the prolificacy by 3/2.

There are indications of differences between breeds but they may be due to the uncontrolled factors mentioned above. Therefore it would be premature to assume that these apparent differences are real.

The prolificacy may not look spectacular compared with the Finnish Landrace or the Chios breed, but the lambing rate per annum justifies the inclusion of all three breeds in the category "highly fertile", and amply bears out the estimate of 200-220 lambs per 100 ewes per year given by Groenewold (1971).

Imported breeds and crossbreeding

The Texel breed was imported by the Dutch and was found satisfactory for crossing both in Bogor and in Bandung. Birth weights and weights at 4 and 6 months were increased by crossing on to Priangan at IPB. There is no information about the effects on fertility, resistance to parasites, or mortality.

The present policy in West and Central Java is to try out the Suffolk, Dormer (Dormer × Merino), and Suffmer (Suffolk × Merino) imported from Australia. Rams of these breeds are being used on Priangan and fat-tailed ewes at several experimental and private farms. It was difficult to obtain exact figures, and the numbers involved are still comparatively small, but it is the author's impression that the imported breeds appear to thrive and reproduce satisfactorily if maintained at an altitude of at least 800 m. and are well fed, clipped frequently



Tails of Javanese fat-tailed ewes near Pamekasan, Madura. (Credit: I.L. Mason)

tered earlier on account of aggressiveness. For ethical reasons castration is not practised.

Prolificacy

For all three breeds it is reported that the ewes normally have one or two lambs at a birth and occasionally three. Certainly the author saw a number of twins, one set of triplets with a thin-tailed ewe near Jogja-

At IPB (Institut Pertanian Bogor - Bogor Agricultural University) figures were provided for small groups of Priangans which suggested prolificacies of 183 and 156 percent. Dr. Sas-tradipradya provided a figure of 135 percent for his flock.

Averaging all the figures for each breed without making any allowance for the different numbers of animals per sample, the different conditions under which they were kept, or the age of the ewe gives the following

and dosed regularly against helminths. However, even at Kaliurang (800 m) the respiration rate of Dormers was 100-150 per minute compared with 40-50 for the local sheep.

Under less favourable conditions there is a high mortality among lambs. Local ewes tend to suffer from dystocia when mated to a Suffolk ram, even when they are carrying twins. The F_1 animals appear to perform satisfactorily if carefully managed.

A comprehensive crossing trial is being undertaken by Gajah Mada University at Jogjakarta. The crossbreeding will take place at three locations: Brebes on the north coast (hot); Kaliurang at 800 m (cool and misty); and Baturadea (cool and clear, good nutrition). There will be three groups: Dormer $\times$ fat-tailed; $F_1 \times$ fat-tailed; and fat-tailed $\times$ fat-tailed. There will be 20 ewes per group in each of the three locations. The sheep will be kept in sheds (with slatted floors) with some grazing time (chiefly for exercise) each day. Mating will be year-round. This trial was due to start in September 1977.

Conclusions

The sheep of Java form an invaluable genetic resource; they should be treasured for their adaptation to an environment traditionally considered difficult for sheep and for their high rate of reproduction. They are an extremely important source of meat in a primarily agricultural area and make no demands in the way of imported feedstuffs or the production of forage crops. Any improvement which is attempted should bear in mind these special advantages.

The Priangan and the East Java fat-tailed are clearly larger and probably more prolific than the local thin-tailed. Improvement programmes should therefore concentrate on these two breeds which should then continue to be used, as at present, to grade the smaller and commoner breed. Two of the Government activities for the genetic improvement of these breeds are particularly relevant. The selection within the Government flock of Priangan sheep at Garut and

the selection programme among the farmers' stock of the fat-tailed sheep in East Java are both excellent initiatives which, it is hoped, will be expanded and intensified. They should produce more productive sheep which still maintain their adaptation and their fertility and therefore can be used on ordinary farms where conditions do not permit a high level of feeding, expensive disease control programmes or other aspects of sophisticated management.

Crossbreeding with temperate breeds may be useful for some farms in favourable situations, but this will probably be restricted to those who can afford the improved management necessary to maintain a more sensitive breed. Before such crossbreeding is generally expanded controlled experiments should be undertaken to compare the purebreds and the crosses under different environmental conditions in order to find out what level of foreign blood is desirable in a given environment. The crossbreeding experiment at Gajah Mada University is an excellent example of the type of investigation which is needed.

Such crossbreeding will improve size and growth rate but, if it does so at the expense of fertility and lamb viability, the overall improvement in production in terms of weight of lamb per ewe per year may be negligible. This must be carefully watched in all comparisons of purebreds and crossbreds.

The crossbreeding with medium- or fine-wool breeds will not improve the wool for the one local outlet: carpet making. For this purpose crossbreeding with a carpet wool breed might be considered, and preferably a carpet wool breed from a hot area such as the Awassi from the Near East or the White Karaman from Turkey. If used in East Java these breeds would have the additional advantage of maintaining the fat tail. On the other hand, in that region the wool appears not to be desired, so a hairy tropical breed might be more appropriate: the Dorper from South Africa or the Sudan Desert sheep. Either should improve body weight without sacrificing tropical adaptation. An interesting idea would be to use

the Barbados Black Belly which combines tropical adaptation, absence of wool and high prolificacy.

If carpet wool production were increased by crossbreeding, a better marketing system would have to be devised which gave the farmer incentives in the form of a higher price for his wool and a more efficient system for collecting it. The carpet factories might consider the manufacture of woven carpets in addition to the more expensive tufted types, and the development of an export market. ■

References

- ADI SUDONO. 1965. *Ilmu Ternak umum*. Diktat Fakultas Peternakan IPB (tidak diterbitkan). (Quoted by Zulbardi, 1977)
- AMBAR RUSYAD. 1977. *Sheep breeds of Indonesia*. (Manuscript)
- ATMADILAGA, D. 1958. Study on the milk yield of Indonesian sheep with special reference to the Priangan breed. *Hemera Zoa*, 65: 3-14.
- BPPP (BALAI PUSAT PENJELIDIKAN PETERNAKAN). 1954. *Laporan tahunan*. Bogor. (Quoted by Ambar Rusyad, 1977)
- BPPP (BALAI PUSAT PENJELIDIKAN PETERNAKAN). 1955. *Laporan tahunan*. Bogor. (Quoted by Ambar Rusyad, 1977)
- BUKU SAKU PETERNAKAN. 1975. *Direktorat Penyuluhan Peternakan*. Djakarta.
- FISCHER, H. 1955. Schafhaltung und Wollverwertung auf der Insel Java. *Tierzüchter*, 7: 331-313.
- GROENEWOLD, H. 1971. *Review of livestock development possibilities, Indonesia*. (Unpublished FAO report)
- MERKENS, J. & SOEMIRAT. 1926. Bijdragen tot de kennis van schapenfokkerij in Nederlandsche Indie. *Nederlandsche Indische Bladen voor Diergeneeskunde*, 38: 395-414.
- ROBINSON, D.W. 1977. *Livestock in Indonesia*. *Peternakan di Indonesia*. Bogor, Indonesia, Centre for Animal Research and Development. Research Report No. 1. P4, Ciawi, Bogor. Laporan Penelitian No. 1.
- ZULBARDI. 1977. *Ternak domba di Indonesia*. *Sheep in Indonesia*. (Manuscript)

Outbreak of sheep scab in Lesotho

P.J. Flower

Lesotho is a small country in an extremely mountainous area of southern Africa, completely surrounded by the Republic of South Africa. Rugged mountains up to 3 300 m high make up three quarters of the land area;

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the remainder is lowlands and foothills averaging between 1 500 and 1 800 m above sea level. Most of the deeper valleys in the heart of the mountains contain permanent habitations, but the bulk of the population lives in the lowlands and foothills. Livestock are herded in a common

land ownership system, grazing the lowlands in winter and the mountains in summer. Communications within the country are mostly difficult, frequently broken by heavy rain or snow; and in many areas, total reliance is placed on equine transport only.

Administratively the country is di-

Sheep scab; a serious threat to Lesotho's wool industry.



Progress of the outbreak of sheep scab from
March 1975 to November 1977

Figure 1 – March 1975

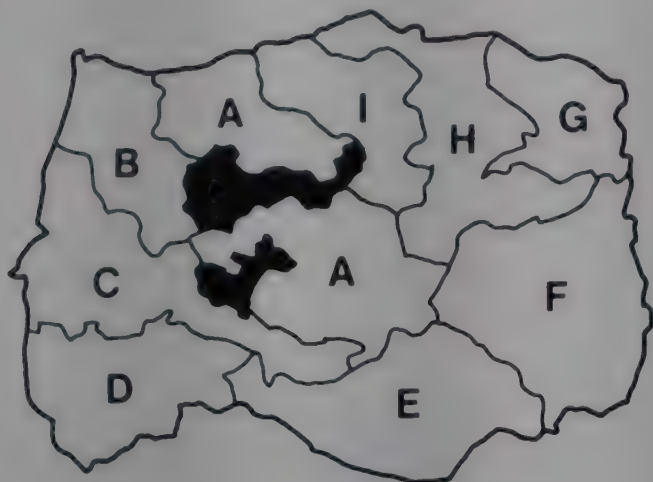


Figure 2 – October 1975

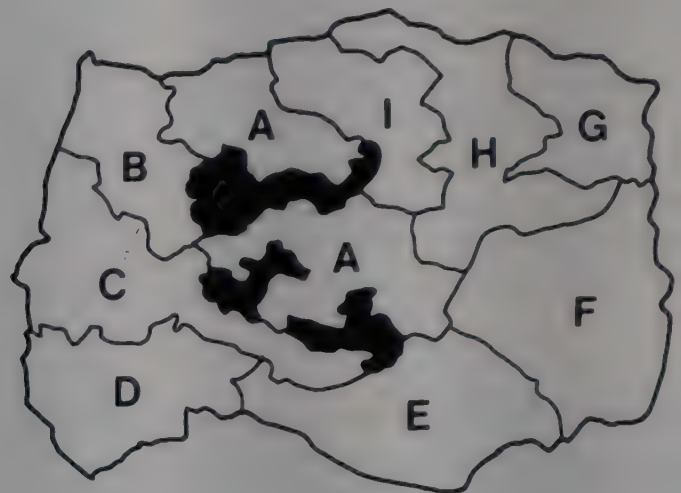


Figure 3 – February 1976

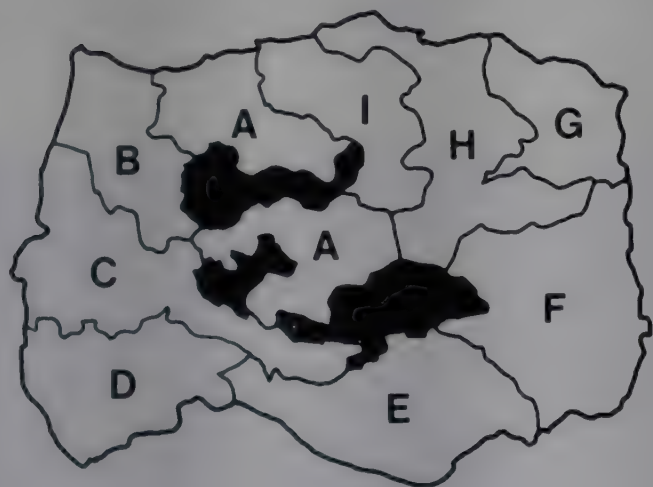


Figure 4 – April 1976



Figure 5 -- October 1976

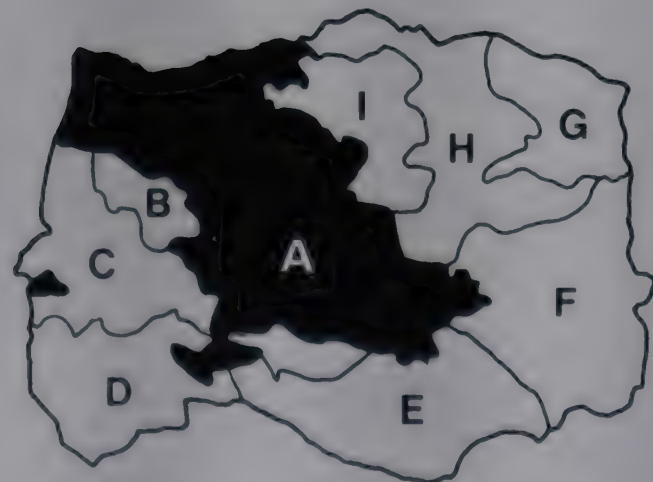
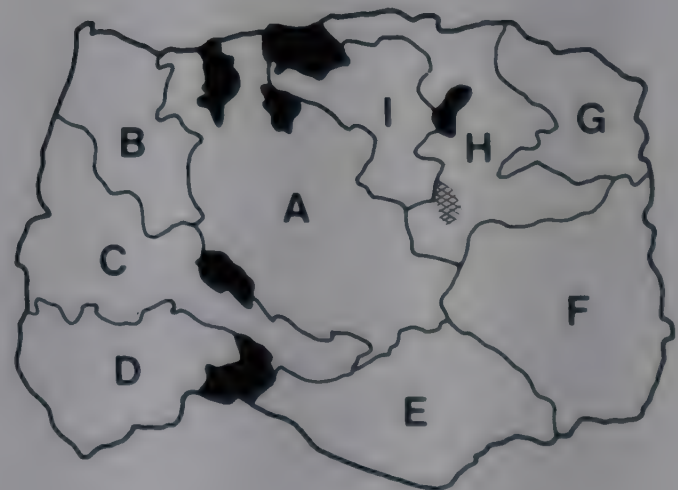


Figure 6 – November 1977



Districts
A – Maseru
B – Mafeteng
C – Mohaies Hoek

D – Quthing
E – Qachas Nek
F – Mokhotlong

G – Butha Buthe
H – Leribe
I – Teyateyaneng

vided into nine districts. Each district is subdivided into dip tank areas, varying in number from 10 to 41; there are a total of 202 dip tank areas in Lesotho, each with its own tank. These areas date back to a sheep scab (*Psoroptes ovis*) eradication campaign which started in 1925 and ended with the successful eradication of the disease in 1935. The size of each area is limited by the distance that a stock owner can drive his animals in half a day.

When dipping ceased in 1935, the dip tanks fell into disuse, but the areas remained well defined in the minds of the farmers, because they continued to be used for administrative purposes and for the implementation of grazing control measures. Between 1935 and 1975 Lesotho was one of the few countries in the world to have eradicated sheep scab. Its eradication enabled considerable advances to be made in sheep husbandry, a development of much importance to Lesotho because wool and mutton are the principal products of the poorer mountainous regions, bringing an annual income of approximately R10 million. (In February 1978 U.S.\$1.00 = 0.867 rand.) The national Merino flock has been steadily improved over time until Lesotho is now able to boast possibly the best flocks in the developing world, but in 1975, with the reintroduction of sheep scab, all of this development was put at risk.

In 1969 the Government introduced the grading and marketing of wool on behalf of Lesotho's farmers. At this time it was realized that the sheep ked (*Melophagus ovinus*) was causing much damage to Lesotho's wool clip, so a ked control project was started between 1970 and 1974, during which 130 of Lesotho's 202 dip tanks were re-opened and dipping after shearing became a routine practice. The dipping was financed by a small levy on the wool and mohair handled by the 93 government shearing sheds.

The shearing sheds and staff are controlled from livestock improvement centres located throughout the country, each centre covering some four to six dip tank areas. The livestock assistants in charge of each centre are trained in soil conservation, grazing

management, animal husbandry, disease recognition and treatment. In addition to the wool shed staff, the livestock assistants have several other technicians under their control; together they constitute a useful force that can be effectively used in the implementation of a nation-wide disease control programme.

Course of the outbreak

MARCH-SEPTEMBER 1975. In March 1975 nine Merino rams were purchased by the Government of Lesotho from a farmer in the Republic of South Africa for breed improvement work in Lesotho. It was not realized at that time that the rams were infested with sheep scab; the skin condition that must have prevailed in the flock from which they were purchased was not made known to the buyers. The rams were distributed on arrival in Lesotho to three areas in Maseru district in the centre of the country: Likalaneng, Simeone and Semonkong/Ramabanta.

In April 1975 the Veterinary Services of the Republic of South Africa were alerted to sheep scab at the farm from which the nine rams had originated; dipping and scab eradication commenced immediately on this farm. But the South African Veterinary Services were not notified of the recent sale of rams from the farm to Lesotho, nor were the Lesotho authorities informed that sheep scab had been confirmed on the farm. Consequently, it was not until July 1975 that the first report of suspected sheep scab in Lesotho resulting from the March importation was received from the Semonkong area. This report was investigated, and sheep scab confirmed. All farmers who had purchased rams from this importation were traced immediately, and it was found that sheep scab had spread to their flocks (Figure 1).

July is the coldest time of year in Lesotho, so that dipping cannot safely be undertaken owing to the high mortality rate that would result from chilling after dipping. Furthermore, sheep cannot be dipped against sheep scab if they have more than six months'

growth of fleece, and since shearing is mostly conducted during October-November, the sheep have about eight months' growth by July. Consequently, no control measures could be instituted until the following spring, when the weather was warmer and the sheep could be shorn. By this time the infected flocks had mostly suffered a 25-30 percent mortality and a 95 percent wool loss.

During August-September 1975 the available compounds for the control of sheep scab were reviewed. The primary consideration was that, in order to dip large numbers of sheep, sufficient quantities of the compound needed to be transported by mule to many of Lesotho's dip tanks. Of the currently available compounds in the subcontinent, it was found that one mule-load of diazinon D.F.F. would dip the same number of sheep as four loads of diazinon miscible oil formulation and twelve of γ -BHC wettable powder; eight litres of diazinon D.F.F. would dip 4 000 sheep and goats. A further consideration was that diazinon D.F.F. has a significant fleece residue period, the exact duration of which is currently under investigation by the Ministry of Agriculture. A lasting fleece residue is very important in a country where grazing practices are such that dipped and undipped sheep will come into contact with each other on communal grazing lands.

The constant replenishment (CR) method of dipping was chosen for its reliability, although it has the disadvantage of requiring extra equipment: two 200-litre mixing drums at each tank. With correct application of the simple rules of operation, there is little chance of making an error in dip concentration when the CR method is used. This is important because if an error resulted in animal deaths, the dipping campaign would suffer a serious set-back and farmers would then be frightened to dip their sheep. Conversely, a low dip concentration would render the dipping ineffective, and if this caused a pocket of scab infestation to remain, it could jeopardize the whole eradication campaign. Errors in dip concentration are automatically corrected when the CR method is used.



Waiting for the dipping to start. In the distance can be seen the wool shed and vaccinating and dosing crush pen.

Many of the sheep and goats of Lesotho are of very good quality stock. Dipping operations can be seen in the background.





Each sheep and goat is marked as it leaves the tank.

SEPTEMBER 1975-APRIL 1976. A localized scab control project was started with assistance from the Government of the United Kingdom. The funds (R109 000) were used mainly for the purchase of diazinon D.F.F., replenishment drums and vehicles, as well as for the reconstruction and repair of non-operational dip tanks critical to the disease control area. During September-October dipping courses were held throughout Lesotho and staff were instructed in sheep scab eradication using diazinon D.F.F. with the CR method.

As soon as the weather was warm enough, the eradication campaign was initiated. A policy of single dipping of infested and in-contact flocks was adopted. In practice, however, it proved impossible to identify all in-contact flocks and overcome the inherent resistance of owners to dip their apparently uninfested sheep and goats. It was easy for a reluctant stock owner to avoid dipping his sheep and goats by simply herding them in a different area where no dipping was taking place.

In October 1975 an area neighbouring Semonkong was reported infested; investigation confirmed the occurrence of sheep scab. It was found that a "lobola payment" (marriage settlement) had been made with infested sheep into the Lesobeng area located in a remote part of Maseru district (Figure 2) to which access is extremely difficult. Control measures were instituted through the nearest livestock centre; the reconstruction of one non-operation tank was also undertaken.

One of the factors that contributed to the spread of sheep scab was that it was illegal for farmers to shear their sheep at home; sheep could only be shorn at government wool sheds. This meant that highly undesirable movements of sheep (including infested sheep) took place. As a direct result, the infestation spread from Lesobeng to the wool shed in Thaba Tseka and thence into the Thaba Tseka area. Some rams were kept for sale at the Thaba Tseka wool shed and were distributed among farmers as far as Mokhotlong district for breed improvement work. By February it was realized that these rams had been infested, and their dis-

tribution had spread the disease as far as Mokhotlong district (Figure 3).

It was now evident that the disease was getting out of control. Several new outbreaks were confirmed among flocks that had returned to the lowlands from summer grazings, some of which were in infested areas (Figure 4).

APRIL-SEPTEMBER 1976. In April 1976 dipping ceased because of the on-coming winter period. As the winter proceeded, more reports of sheep scab were received, and, as had been feared earlier, the 1975-76 control programme really proved to have been ineffective in controlling the disease. Scab was reported in the whole central region of the country; the disease also spread to Quthing district when a shepherd boy was paid with infested sheep for his work; and seasonal sheep movements helped to spread it further to Qachas Nek district (Figure 5).

An isolated outbreak of sheep scab was confirmed in Mophales Hock district near a border gate, but it was dipped out without further spread.

The national dipping campaign 1976-77

Policy formulation. In September 1976 the Ministry of Agriculture was faced with the situation that scab had been confirmed in about half of the country's dip tank areas, although only about 15-20 percent of sheep were infested. Since it was not possible to identify the infested sheep individually, the eradication programme was developed on the basis that the whole country was affected.

The dipping policy was formulated with three principal objectives:

- to stop further mortality in seriously affected flocks;
- to contain the disease to known areas;
- to eradicate sheep scab from Lesotho.

Factors taken into account in drawing up the dipping campaign. (a) Social and economic considerations affecting stock movements. During the

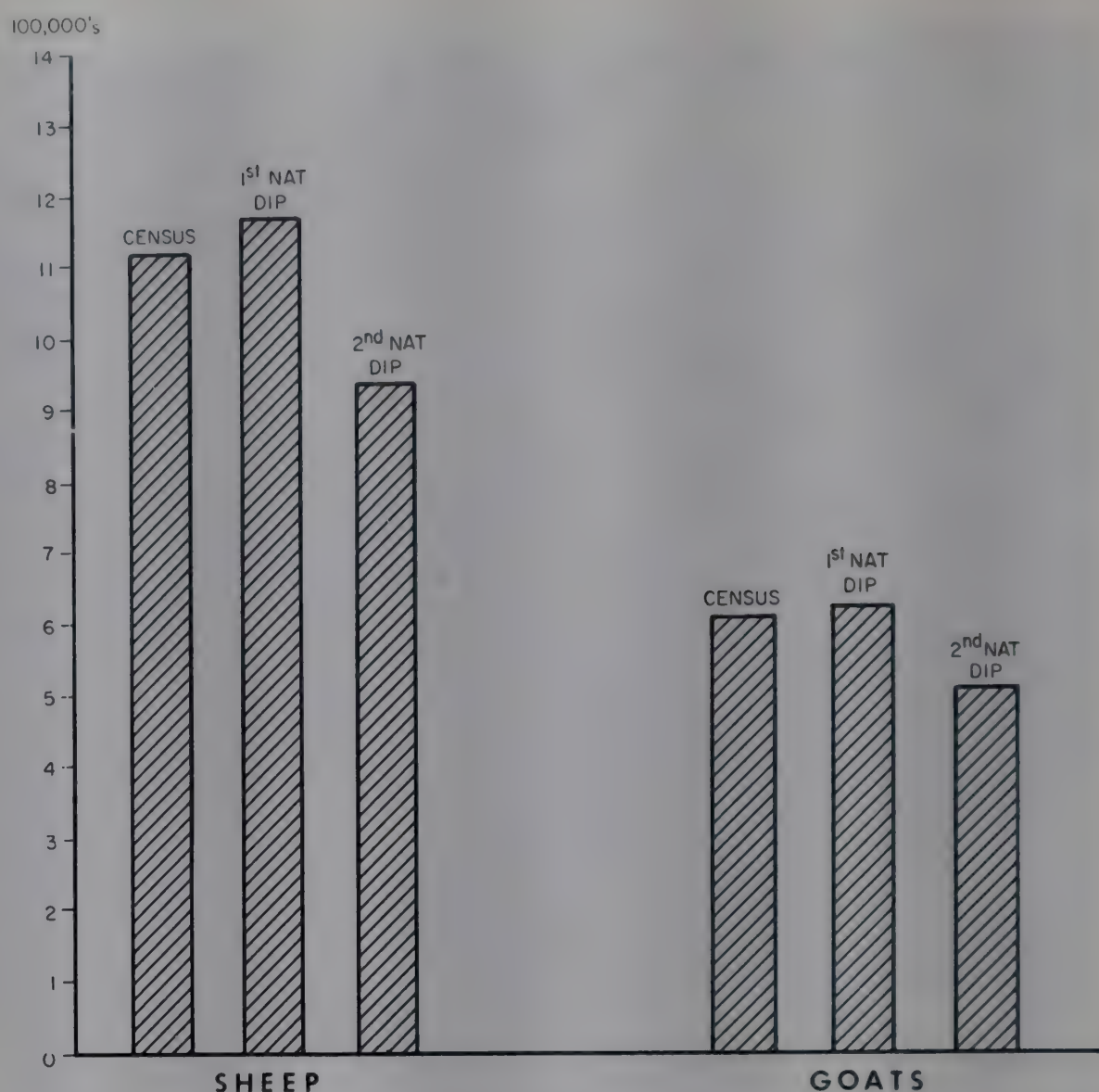


FIGURE 7. Total census (1976) and dipping figures (1976-77).

summer months stock have to be moved up to the mountains because of the paucity of the grazing available on the lowlands as a result of cultivation. The movement up to the mountains normally takes place during November-December, and the return to the lowlands during March-April. Since it is not reasonable to impose restrictions on the movement of stock during these periods, it was decided that the national simultaneous dipping campaign to be organized in the country should be conducted outside of these periods as the only realistic way of attempting to eradicate the disease. (b) Conditions governing shearing time. Shearing starts as soon as it is warm enough in September-October, and does not usually near completion until February. It was agreed that a special effort should be made for the shearing to be completed by 1 Jan-

uary; this would facilitate initiation of the national simultaneous dipping campaign immediately after, and its completion before the autumnal stock movements commenced.

(c) Expected standard of dip tank management. Dip tank management is a crucial factor in a campaign of this nature. Staff were instructed that every sheep should be immersed for at least half a minute, and submerged three times, although it was recognized that this may not always happen in practice. A single dipping is claimed as sufficient treatment, but double dipping would reduce the likelihood of continuing infestation that may occur due to poor tank management.

(d) Fleece residue of diazinon D.F.F. The desirability of double dipping raised the question of the optimum time interval between one dipping and the next. Diazinon was known to have

an acaricidal fleece residue from a single dipping of at least 11 days, but how much longer was unknown. A simple trial was therefore conducted by the Ministry of Agriculture which indicated that the acaricidal fleece residue from one dipping was 42 days and that from a double dipping 88 days. These results were not considered conclusive; a more detailed trial is to be conducted. Nevertheless, sufficient acaricidal fleece residue was present on the fleece to ensure adequate protection from re-infestation in case dipped sheep should contact undipped infested sheep during the months of dipping.

(e) Legal and political support for dipping. The Government gave its fullest support at all times to the dipping campaign, though it was found that some revision of the dipping laws was necessary.

Dipping policy. The three objectives of the dipping campaign were met by devising a three-stage dipping policy.

I. Preliminary dipping: A single voluntary dipping to take place any time before 1 November 1976, to be paid for by the farmers. The purpose was to stop continuing mortality in badly infested flocks.

II. Infested area dipping: A free and compulsory double dipping at 10-14 days' interval between 1 November and 31 December 1976 in the known infested areas. This dipping was aimed at stopping further spread of infestation during the shearing period.

III. National dipping: A free and compulsory double dipping at 10-14 days' interval to take place during January and February; all the sheep and goats in Lesotho were to be dipped during this two-month period, irrespective of whether they had previously been dipped or not. The sheep and goats were to be marked with a red or blue dye at each dipping, and certificates of dipping were to be issued to each farmer. At the same time a restriction order was issued forbidding the movement of sheep and goats across dip tank boundaries and the importation of sheep except for slaughter. This national dipping campaign was aimed at the eradication of sheep scab from Lesotho.

Information for farmers. A publicity campaign was conducted using slide presentations, posters and the radio, to inform the farmers throughout Lesotho of the dangers of sheep scab and the need for dipping.

Three information units were sent to all the major villages in Lesotho; field staff showed slides of sheep scab infestation and answered technical questions on the disease and its control.

Two types of posters were widely distributed in all districts. The first posters informed farmers of the dipping laws; later ones displayed pictures of infested sheep and announced the dipping dates at each dip tank.

Radio Lesotho was constantly used to disseminate information about sheep scab, dipping and the use of the law to enforce dipping.

Preparation for dipping. In September 1976, at the start of the warm season, six builders were employed and trained in dip tank construction and repair. Most of the unused 72 dip tanks were repaired, and several of the existing dip tank water supplies were improved during the ensuing seven months of summer.

During this period, great difficulties were experienced in supplying the builders with transport. Two mule trains and eight four-wheel-drive vehicles were used, and at times were found to be insufficient on account of the extremely rough terrain which caused frequent breakdowns.

The application of the dipping policy. The preliminary dipping and the infected area dipping were not as successful as had been hoped. Few farmers brought their animals for the preliminary dipping, preferring to risk deaths until the dipping became free of cost as from 1 November. The difficulty of delineating the infested areas was the principal reason for the lack of success in the second stage of the dipping policy. Some farmers remained genuinely ignorant of the likelihood of their animals acquiring the infestation after contact with infested sheep, while others argued with field staff very strongly that their flocks were not visibly infested, and

therefore there was no need to dip.

The national dipping was successful in reducing the incidence of sheep scab, though it failed to eradicate the disease. The intended start of the national dipping had to be delayed until February due to an exceptionally wet season which delayed shearing; the period of national dipping itself had to be extended to three months owing to the continuing bad weather.

The first national dipping was very well attended, but there was a serious shortfall in the number of animals presented for the second dipping (Figure 7). Nevertheless, it is indeed an achievement for the Ministry of Agriculture that approximately the same number of sheep and goats as were recorded in the 1976 official census were dipped at one dipping. The lower numbers at the second dipping were due partly to the bad weather which delayed shearing; the restrictions on movement had therefore to be lifted before the dipping was complete in order to permit the seasonal migration to the lowlands to take place. It was also due partly to the strong tendency among farmers to feel that one dipping was adequate.

Between July and November 1977, eleven new outbreaks of sheep scab were reported in ten dip tank areas, one of which had not previously been recorded as an infested area (Figure 6). Nine of the new outbreaks were traced to owners who had only dipped their sheep and goats once, and steps were taken immediately to bring these owners to court. Of the other two outbreaks, one was traced to an owner who dipped his sheep and goats correctly, but did this in a dip tank that was incorrectly managed; this was not discovered until the end of the dipping season. The other outbreak which occurred in the newly infested area was traced to an owner who had not dipped his sheep at all; these sheep had been grazing in an area with infested sheep.

Although the 1976-77 dippings failed to eradicate scab from Lesotho, the small number of reported outbreaks does indicate that the disease has now been brought under control through the vigilance of the field services of the Ministry of Agriculture. ■

Recent research on controlled reproduction in beef cattle

Practical applications

**J.N. Wiltbank
and J.C. Spitzer**

Two approaches have been used to control reproduction in beef cattle: management systems, and exogenous hormones. Hormonal control has not been found to be effective until at least partial control is attained through improved management. In this article, management systems which provide some control will be outlined. A hormonal regime which has been used for controlling and inducing oestrus will also be briefly discussed.

Reproductive losses. To attain control of reproduction in a beef herd, breeding and calving must occur within limited periods of time, but in an effort to increase the percent of calf crop, most beef herds breed and calve over extended periods of time. Under these conditions, control is limited or non-existent, and calf crop and weaning weight are generally decreased.

A ranch in the gulf coast region of south Texas would serve as an ex-

ample of the effect of a long breeding and calving season on reproductive performance. A 180-day breeding season has been traditional on this ranch, and bulls have been placed with cows from the first week of February. Generally, a 60-70 percent calf crop (i.e., percent calves weaned per cow bred) has been weaned on this ranch. The managerial causes for reduced calf crop were studied in one herd from this ranch. Seventy-seven percent of the cows were diagnosed pregnant, 2 percent were diagnosed pregnant but did not calve, and 11 percent lost their calves at or after

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Figure 1 Calves at weaning time from cows in conventional management system. Note variation in size of calves. Compare with uniform calves in Figure 2.



TABLE 1. Effect of a long calving season on percent calf crop

	Cows at start of breeding season	Cows pregnant	Cows calving	Calves weaned
	Percent			
South Texas	135	77	75	64
Louisiana				
1st year	226	72	69	64
2nd year	236	82	79	61
Virginia				
1st year	453	88	85	75
2nd year	429	88	86	68

birth (Table 1). Similar results which have been previously reported for beef herds studied in Louisiana and Virginia are also shown in Table 1 (Wiltbank *et al.*, 1961).

The reason for the low pregnancy rate in these herds was the long calv-

TABLE 2. Effect of calving time on pregnancy and occurrence of oestrus in a Texas beef herd

Days after start of breeding season	Cows pregnant		Cows showing oestrus	
	Calved before start of breeding season	Calved after start of breeding season	Calved before start of breeding season	Calved after start of breeding season
	Percent			
60	70	36	90	46
120	85	57	99	69
180	88	60	99	71

ing season. This can be demonstrated by using the south Texas herd as an example. Eighty-eight percent of the cows calving before 1 February became pregnant during the 180-day breeding season as compared to 60 percent in the case of cows calving after 1 February (Table 2). In addition, more cows calving before 1 February became pregnant early in the breeding season. The main reason for

these differences in pregnancy rate was the proportion of cows that had shown oestrus. Ninety percent of the cows calving before 1 February exhibited oestrus in the first 60 days of the breeding season, while only 46 percent of the late calving cows exhibited oestrus during this period. After 180 days of breeding, the percent in oestrus increased to 99 and 71 percent respectively for early- and late-calving cows.

Few additional cows showed oestrus or became pregnant between 120 and 180 days of the breeding season. The increase in pregnancy rate in late calving cows was only 3 percent and the increase in oestrus was only 2 percent. The breeding season could be shortened by 60 days in this herd without appreciably decreasing reproductive performance. A shortened breeding and calving season would appear important in increasing reproductive performance in this cow herd.

Puberty in heifers. Short breeding and calving seasons in cow herds can only be achieved when heifers calve early in the desired breeding season. To accomplish this, heifers must show oestrus and conceive early in their first breeding season. This necessitates heifers reaching puberty either prior to or early in the breeding season. Available data indicate that heifers must attain a certain weight and age in order to reach puberty, the age and

Figure 1 Calves at weaning time from cows in new management group. Note uniformity of size.



TABLE 3 Weight at which 14- to 15-month-old heifers¹ show first oestrus

Proportion showing oestrus	Weight needed						
	Br × E ²	Angus	Hereford	Charolais	A × H	S × E	SG
Percent							
50	295	250	275	320	250	295	295
65-70	320	275	295	330	275	320	320
85-90	340	295	320	340	295	340	340

¹ Br × E and SG need to be 16-17 months for same level of response. — ² Br = Brahman; E = Hereford and Angus; A = Angus; H = Hereford; S = Simmental; SG = Santa Gertrudis.

weight needed varying according to the breed of the heifer. Eighty-five to 90 percent of the heifers in most breeds in the United States will attain puberty at 14-15 months of age, provided that they have sufficient weight. The exceptions to this are Brahman heifers, Brahman crossbred heifers, and heifers of some breeds based on crosses with Brahman. The age at which approximately 90 percent of Brahman crossbred heifers will show oestrus, provided that sufficient weight is attained, is 16-17 months, while purebred Brahman heifers may need to be 20 months or older. Some experience of breeders indicates that age at puberty in Brahman heifers can be decreased by selection.

A summary of the available data on weight necessary to have heifers of various breeds reach puberty is shown in Table 3. As an example, 50 percent of the Angus heifers weighing 250 kg should have shown oestrus at 14-15 months of age. The number of 14- to 15-month-old Angus heifers reaching puberty would increase to 65-70 percent at 275 kg and to 85-90 percent at 295 kg. Hereford heifers must weigh 20-25 kg more at the same age to have identical proportions when they reach puberty. Many Brahman crossbred heifers would need to weigh 40-45 kg more than Angus and be 16-17 months of age to achieve the same results.

In one study, Hereford heifers were divided into three groups based on weight at the start of the breeding season. The pregnancy rate was 65 percent after 60 days of breeding in heifers weighing less than 250 kg at the start of breeding, compared with 90 percent in those weighing over 273 kg at

the start of breeding (Table 4). Calf loss was higher in the light heifers than in heavier heifers. The difference between heifers diagnosed pregnant and calves weaned was 25 percent in light heifers, and 4-6 percent in the heavier heifers.

The proportion of cows calving in year one that were pregnant the second year was 18, 57 and 69 percent in heifers weighing less than 250 kg, between 250 and 273 kg, and over 273 kg at the start of their first breeding season, respectively. These data indicate three reasons for decreased reproductive performance in heifers which are light at the start of the breeding season: decreased pregnancy rate at first breeding; higher calf losses; and fewer rebreeding for their second calf.

TABLE 5. Comparison of reproductive performance and productivity in new management and conventional management systems¹

	New system	Conventional system
Length of breeding season	45 days	90 days
Number of heifers exposed	137	86
Heifers pregnant after breeding (%)		
25 days	² 59	³ 44
45 days	² 74	³ 59
90 days	—	83
Number of cows exposed	195	199
Cows pregnant after breeding (%)		
25 days	² 74	³ 60
45 days	87	78
90 days	—	92
Average weaning weight (adjusted to bull basis)	² 203 kg	³ 188 kg

Source: Spitzer et al. (1975).

¹ Five-year study. — ^{2,3} Figures with different superscripts on same row differ significantly ($P < .05$).

TABLE 4. Weight at start of first breeding season and reproductive performance of Hereford heifers

	Weight at start of breeding		
	Less than 250 kg	250-273 kg	Over 273 kg
Number of heifers	40	166	45
	Percent		
Pregnant after 60 days of breeding	65	77	90
Calves weaned	40	71	86
Pregnant second breeding season	18	57	69

A management system to improve reproductive performance

A management system incorporating the ideas discussed above has been reported by Spitzer (1975). In the new management system the breeding season started 20 days earlier in heifers than in the regular cow herd, synchronization of oestrus was used, heifers were selected for early pregnancy, and both heifers and cows were bred in a 45-day breeding season. In contrast, cows and heifers in the conventional system were bred for 90 days, the breeding of heifers started

the same day as the regular cow herd, and no selection for early calving was practised. All open cows and heifers in both groups were culled at the end of their respective breeding seasons. Cows in the new and conventional management groups were on the same pastures and were fed for maximum reproductive performance. The new management system caused the heifers to calve early, and cows and heifers calved in a short period of time; by contrast, heifers and cows in the conventional system had a long calving season.

Fifty-nine percent of the heifers in the new management group became pregnant in the first 25 days of the breeding season compared to 44 percent ($P < .05$) in the conventional management group (Table 5). Similar differences were apparent after 45 days of breeding.

Pregnancy rates in the cows differed by 14 percent ($P < .05$) after 25 days of breeding, 9 percent after 45 days ($P > .05$), and 5 percent ($P > .05$) at the end of the breeding season; the length of the breeding season was 45 days in the new management group and 90 days in the conventionally managed group.

While the pregnancy rate over five years did not differ, more of the new management heifers and cows calved



Figure 3 Placing an SC21009 implant in the ear.

early and in a shorter period of time (Table 6). Seventy-five percent of the heifers in the new management group had calved by the tenth day of the calving season, whereas it was the fiftieth day of the calving season before a comparable number of heifers had calved in the conventional management system. Seventy-six percent of the cows in the new management group had calved by day 30 of the calving season, while it was day 50 of the calving season before an equal percentage of conventionally managed cows had calved. This earlier calving in the heifers and cows caused an increase in weaning weight of 15 kg in calves in the new management group.

TABLE 6. Calving pattern in new management and conventional management systems

	Heifers		Cows	
	New system	Conventional system	New system	Conventional system
Number of animals	137	86	195	199
Percent pregnant	74	83	87	92
Percent of the pregnant animals that calve within 10 to 110 days of calving season				
10 days	75	3	22	8
20 days	88	42	56	27
30 days	100	59	76	49
50 days	—	78	97	76
70 days	—	89	100	87
90 days	—	93	—	97
110 days	—	100	—	100

Source: Spitzer, Willbank and LeFever (1975).

Data from this study indicate that management systems which employ techniques for shortening the breeding and calving seasons can improve reproductive performance and calf weaning weight.

Exogenous hormonal control

Hormones have been used for several years to control reproduction in beef cattle. Treatments have had limited success in most cases. Oestrus has been successfully synchronized in animals which have had an oestrus period prior to the time of treatment, but little or no success has been noted in animals which were anoestrous at the time of treatment. Hormonal treatments cannot be successful in beef herds unless they control ovulation time in cycling heifers and cows, and induce ovulation in heifers which are prepubertal at time of treatment and in cows which are anoestrous at time of treatment. A series of experiments utilizing the Syncro-Mate-B treatment (SMB) were designed to accomplish these two goals.

SMB consists of an implant containing 6 mg norgestomet and an injection of norgestomet and estradiol valerate. The implant is placed subcutaneously in the convex surface of the ear and remains *in situ* for 9 days. Implanting is done with a tool similar to one used in implanting stilboestrol. The implants are easily removed using a scalpel blade or a knife. The injection is given intramuscularly at the time the implant is placed in the ear. The SMB treatment does not interfere with established pregnancies.

Early studies (Spitzer *et al.*, 1978a, 1978b) indicated that 75-80 percent of heifers treated with SMB had shown oestrus by 48 hours after implant removal. Fertility rates in most trials were comparable to those noted in the controls. Several studies indicated that a single timed insemination following SMB treatment would give satisfactory pregnancy rates without the need for detecting oestrus.

In one such study Angus and Angus $\times$ Simmental heifers which were 14-15 months old and weighed 295-341 kg were divided into four

TABLE 7. Pregnancy following SMB treatment in heifers

Treatment		In oestrus 21 days	Pregnant after first insemi- nation	Pregnant after 5, 21, 27 and 90 days of breeding			
				5 days	21 days	27 days	90 days
	Number			Percent			
Control	53	94	54	21	51	60	83
SMB-bred at heat ¹	48	100	65	65	71	75	94
SMB-bred 48 hrs ²	49	⁴	55	55	63	73	86
SMB-bred 54 hrs ³	48	⁴	52	52	56	69	88

¹ Bred approximately 12 hrs after oestrus was observed. — ² All heifers bred approximately 48 hrs after implant removal. — ³ All heifers bred approximately 54 hrs after implant removal. — ⁴ Not checked for oestrus during synchronized oestrus.

groups by breed and age (J.C. Spitzer, unpublished data). One group of heifers treated with SMB was inseminated approximately 12 hours after the animals were detected in oestrus (SMB-12), while all heifers in two other groups treated with SMB were inseminated either 48 hours (SMB-48) or 54 hours (SMB-54) after implant removal. An additional group of heifers served as controls (C) and were inseminated over a 21-day period approximately 12 hours after detection of oestrus. The pregnancy rate after first insemination was: 54 percent for C; 65 percent for SMB-12; 55 percent for SMB-48; and 52 percent for SMB-54 (Table 7). These data indicate that the pregnancy rate was 10-33 percent less in treated heifers bred at a predetermined time compared with treated heifers bred 12 hours after detection of oestrus. The pregnancy rate, however, was greater in all groups of treated heifers than control heifers after 5, 21, 27 and 90 days of breeding. Insemination at a predetermined time after SMB treatment can be effective in causing a large

number of heifers to become pregnant early in the breeding season.

The SMB treatment has been used for induction of oestrus in prepubertal heifers. In one study heifers were checked for oestrus for 21 days and heifers which were not detected in oestrus were divided equally into treated and control groups by breed, weight and age (Gonzalez-Padilla, Wiltbank and Niswender, 1975). Detection of oestrus continued in controls for 21 days and 28 percent were detected in oestrus (Table 8). By contrast, 79 percent of the SMB-treated heifers were detected in oestrus by four days after implant removal and 84 percent by 21 days after implant removal. Fifty-eight percent of the treated heifers and 11 percent of the control heifers were pregnant at the end of a 21-day breeding period.

These results in prepubertal heifers should be viewed with some caution. The heifers utilized in this trial and in the other studies mentioned were at least 14 months old and most weighed 250 kg or more. Several studies conducted to determine the effect of weight on the response to SMB have provided support to the potential use of SMB treatment for the induction of a fertile synchronized oestrus in prepubertal heifers with body weight as one important factor affecting the response. SMB will not induce oestrus in all heifers. Generally, heifers should weigh at least 250-295 kg, and be 14-15 months old at time of treatment.

The SMB treatment has also been utilized with good results in cows nursing calves. Miksch *et al.* (1978) reported that 90 percent or more of the cycling cows suckling calves treated with SMB showed oestrus by 120 hours after implant removal and 56-64 percent became pregnant by four days after implant removal. When SMB was used in thin, anoestrous cows suckling calves, less than 10 percent became pregnant (Smith *et al.*, 1978). However, oestrus was induced in a high proportion of anoestrous cows suckling calves following SMB treatment combined with 48-hour calf removal at the time of implant removal. This treatment, known as the Shang treatment, was suggested by Mr. Lon Cartwright, a rancher from Dinero, Texas.

Figure 4 Group of heifers during synchronized oestrus.



TABLE 8. Use of SMB in non-cycling heifers

	Number	After 21 days of breeding	
		Showed oestrus	Pregnant
		Percent	
Treated	77	28	11
Control	81	84	58

Source: Gonzalez Padilla *et al.*

TABLE 9. Oestrus and pregnancy following treatment with SMB and Shang in cows suckling calves

Treatment	Number of cows	Inseminated 21 days ¹	Pregnant after implant removal ¹ (accumulative)					Pregnant after one insemination
			5 days	21 days	27 days	45 days	76 days	
Percent								
Control	134	66	16	45	53	70	87	68
SMB	144	68	29	44	56	75	92	49
Shang	133	²	43	59	65	80	95	43

Source: J.C. Spitzer (1976) — unpublished.

¹ Inseminated by 21 days after implant removal. — ² Oestrus was not detected; all cows were bred 48 hrs after implant removal.

The Shang treatment was used in several studies (Smith *et al.*, 1978) and the results indicated that oestrus could be induced in anoestrous cows. Oestrus was found to occur within a period of 24 to 48 hours after implant removal in most anoestrous or cycling cows. This would allow cows to be inseminated at a predetermined time (48 hours after implant removal).

A study conducted by J.C. Spitzer (1976 - unpublished) can serve as an example of the value of the Shang treatment. Four hundred and eleven cows suckling calves in moderate-to-thin body condition were divided by cow age, body condition, calving date and breed into a control group, SMB group and a Shang group. Cows in the control group and the SMB group were inseminated 12 hours after detection of oestrus, while insemination of cows in the Shang group occurred 48 hours after implant removal.

Sixty-six percent of the control cows were detected in oestrus during the first 21 days of the breeding season (Table 9). These data would indicate that at least 30 to 40 percent of the cows in the two groups receiving the SMB and Shang treatments had not shown oestrus prior to treatment. Only 59 percent of the cows receiving the SMB treatment were detected in oestrus by five days after implant removal, indicating that SMB controlled oestrus only in those cows which had shown oestrus prior to treatment or were near oestrus at time of treatment. The pregnancy rate 21 days after implant removal in SMB cows and control cows was similar, indicating again that little or no induction of oestrus had occurred with the SMB treatment

alone. By contrast, the pregnancy rate in cows receiving the Shang treatment was 14 percent higher 21 days after implant removal and was higher throughout the remainder of the breeding period. The pregnancy rate after a single insemination was lower in the SMB- and Shang-treated cows. This could indicate that certain cows which had not shown oestrus or ovulated were inseminated when cows received the Shang treatment. Additionally, data have been reported showing that the conception rate is reduced when large numbers of cows are bred in a short period of time (Spitzer, Miksch and Wiltbank, 1976).

A word of caution concerning the use of the Shang treatment is necessary. Many thin cows on inadequate levels of feed have received the Shang treatment and little or no response has been obtained. The Shang treatment is not a cure-all; cows must be in reasonable body condition and be receiving adequate levels of feed at the time of treatment to obtain a response. Cows that are 50-60 days post-partum at time of implant removal show a better response than cows that are 20-30 days post-calving at treatment time.

Summary

Reproduction can be controlled by a combination of management systems and exogenous hormones. However, little or no control can be achieved with exogenous hormones unless proper management systems are utilized prior to exogenous hormone treatment. The management system discussed for control of reproduction includes: short

breeding and calving seasons; feeding heifers to reach puberty early in their first breeding season; selecting heifers for early calving; and manipulation of suckling. One method for hormonal control of oestrus has been discussed, as well as a regime utilizing this method and manipulation of suckling. ■

References

- GONZALEZ-PADILLA, E., WILTBANK, J.N. & NISWENDER, G.D. 1975. Puberty in beef heifers. II. Effect of injections of progesterone and estradiol 17B on serum LH, FSH and ovarian activity. *J. Anim. Sci.*, 40: 1105-1109.
- MIKSCH, E.D., MUKEMBO, G., LEFEVER, D.G. & WILTBANK, J.N. 1978. Synchronization of oestrus in beef cattle. II. Effect of an injection of norgestomet and an estrogen in conjunction with a norgestomet implant in heifers and cows. Submitted to Anim. Repro. Sci.
- SMITH, M.F., BURRELL, W.C., SHIPP, L.D., SPROTT, L.R., SONGSTER, B. & WILTBANK, J.N. 1978. Hormone treatments and use of calf removal in postpartum beef cows. Submitted to Anim. Repro. Sci.
- SPITZER, J.C., WILTBANK, J.N. & LEFEVER, D.G. 1975. Increase beef cow productivity by increasing reproductive performance. Colorado State University Experiment Station, General Series 949. Fort Collins, Colo.
- SPITZER, J.C., MIKSCH, D. & WILTBANK, J.N. 1976. Synchronization following norgestomet and 5 or 6 mg EV. *J. Anim. Sci.*, 43: 305 (Abstr.).
- SPITZER, J.C., BURRELL, W.C., LEFEVER, D.G., WHITMAN, R.W. & WILTBANK, J.N. 1978a. Synchronization of oestrus in beef cattle. I. Utilization of a norgestomet implant and injection of estradiol valerate. Submitted to Anim. Repro. Sci.
- SPITZER, J.C., JONES, D.L., MIKSCH, E.D. & WILTBANK, J.N. 1978b. Synchronization of oestrus in beef cattle. III. Field trials in heifers using a norgestomet implant and injections of norgestomet and estradiol valerate. Submitted to Anim. Repro. Sci.
- WILTBANK, J.N., WARWICK, E.J., VERNON, E.H. & PRIODE, B.M. 1961. Factors affecting net calf crop in beef cattle. *J. Anim. Sci.*, 20: 409-415.

Crossbreeding N'Dama and Jersey cattle in Ivory Coast

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The low productivity of tropical cattle is one of the reasons for the imbalance in the worldwide meat market. The developing countries possess 70 per-

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cent of the world's cattle and buffaloes, yet produce only 34 percent of the beef; thus, the productivity per head of cattle is 4.5 times lower in the developing countries.

The coastal countries of the Sudan-Guinean zone have only small national herds. It is estimated that the na-

tional herd of trypanotolerant cattle in Ivory Coast is 380 000 head; 320 000 of these belong to the so-called "Baoulé" breed, but in fact most of them are, to a greater or lesser extent, crossbred with either zebu or N'Dama. The remaining 60 000 are humpless N'Dama, which are located

Jersey bull used in Jersey × N'Dama crossbreeding programme.



in the western part of the country and bred on the Aboukouamekro and Sipilou ranches. To this population should be added 100 000 zebu, most of which came north at the time of the great drought in the Sahel.

Almost 90 percent of the cattle spread out north at the eighth parallel in the Sudan-Guinean zone, grazing the natural savanna in a low productivity system. However, as a result of the work of the Société pour le développement des productions animales and of the research on forage and fodder crops conducted by the CRZ,¹ the technical transformation of various stock farms is being accelerated through sound management of the savanna, livestock upgrading techniques, the intensive production of forage and fodder crops outside the scheme of crop rotation, and seed production. In each of these various fields there are definite and important possibilities, and it should also be noted that Ivory Coast has an abundance of agro-industrial by-products useful for feed.

The major problem is one of obtaining cattle breeds that are genetically adapted to the climate, sufficiently trypanotolerant, and capable of converting these enormous feed resources into livestock products in a way that is economically feasible and suits the facilities of the stock farmer.

Selection among local breeds is done to increase the number and performance of cattle. This work is indispensable and must be pursued and intensified, but will not alone meet the need for rapid development of beef production.

Crossbreeding, however, does offer a great potential but it also involves great risks. This article examines its potential for increasing individual production and herd numbers, as well as for determining the limits of the resistance of cattle to the difficult Sudan-

Guinean climate and their tolerance to trypanosomiasis, by presenting a ten-year record of experimentation of Jersey $\times$ N'Dama crossbreeding.

Choice¹ of animals. Of the breeds available in Ivory Coast the N'Dama first caught the attention of breeders due to its larger size, its carcass quality and its trypanotolerance. The CRZ, which had started a selective breeding programme of the N'Dama in 1955, possessed by 1964 a rather homogeneous N'Dama herd with known individual performance that could be used as foundation stock for crossbreeding. That same year, in compliance with directives from the Minister of Agriculture and in view of the encouraging results obtained at the Centre d'élevage (Animal Breeding Centre) of Binger-ville, the committee in charge of research programmes in animal husbandry and veterinary medicine invited the CRZ to undertake an experimental project for the upgrading of N'Dama cattle by introducing the Jersey breed. As previous trials had shown that it was possible to raise N'Dama cattle throughout Ivory Coast (including the coastal zone), it would be feasible to do extension work on crossbreeding if this experiment were also to give positive results. The Jersey breed was chosen for reasons of physiology and husbandry and because of the goals of the first phase of the desired upgrading.

Owing to the poor results obtained in the past in trials with artificial insemination of trypanotolerant cattle, natural mating had to be employed and a bull selected that was compatible in size with the N'Dama cow. Moreover, physioclimatological work had shown that the larger size obtained by crossbreeding might upset the heat regulation process through alteration of weight/body size ratio.

The aims of the crossbreeding were:

(i) to improve milk production in the vicinity of the large urban centres of Ivory Coast; and (ii) to test the extent to which the introduction of genes for milk production into the N'Dama genotype would make it possible to obtain earlier maturing beef cattle through the better nutrition of

calves during the suckling period.

The milk production of the N'Dama cow is generally sufficient to feed the calf up to a certain stage of growth; animals crossed with large sized beef breeds would, if natural suckling were allowed, have to go through an initial stage of improvement of their milk production. Furthermore, it was also considered advisable to test not only the adaptation of the various crossbred progeny to the environment, but also their disease resistance.

The crossbreeding plan. Trials were designed for the breeding and testing of animals of the following grades: 1/2, 3/4, 7/8 and 5/8 Jersey.

The decreased hardiness observed in 3/4 Jersey animals led, in 1971, to the proposal to abandon the upgrading process and to try to produce 3/8 Jersey-5/8 N'Dama animals instead. Thus a type of animal better adapted to the more usual stock-raising conditions in Ivory Coast was sought, which would be used to breed early maturing beef cattle, particularly through the combined effects of heterosis and better feeding of calves, while at the same time allowing a small amount of the milk to be marketed (provided that this did not adversely affect the growth of the calves).

Males and females with different proportions of Jersey and N'Dama breeding were obtained as follows: 192 halfbreds, obtained by mating Jersey bulls with N'Dama cows; 343 3/4-breds, obtained by mating Jersey bulls with F_1 cows (256), or by the interbreeding of the 3/4-breds themselves (87); 236 3/8 Jerseys, obtained by mating N'Dama bulls with 3/4-bred cows (39), or by mating 3/4-bred bulls with N'Dama females (182), or by interbreeding the 3/8-breds (15); 112 5/8-breds, obtained by mating 3/4-bred bulls with F_1 cows.

Rearing conditions. Parallel with the genetic improvement project, the CRZ conducted a programme for the intensive production of forage and fodder crops, thus providing a basis for the feeding system.

The conditions of calf rearing were closely linked to the genetic level of the dams. Lactating mothers were

¹ The project for crossing of Jersey $\times$ N'Dama cattle conducted at the Centre de recherches zootechniques (CRZ, Animal Husbandry Research Centre) of Bouaké-Minankro was launched in 1965. It was executed by J. Coulomb and R. Cadot from 1965 to 1970; and by L. Letenneur, J.C. Mathon, J. Charray, G. Roberge, J.L. Messenger, L. Glattleider, B. Carino and L. Hermitteau from 1970 to 1976.

TABLE 1. Liveweight gains (kg) of N'Dama and Jersey $\times$ N'Dama crossbred males

	N'Dama	F ₁	N'D $\frac{3}{8}$ $\times$ $\frac{3}{4}$	N'D $\frac{3}{8}$ $\times$ $\frac{3}{4}$	$\frac{3}{4}$ J $\times$ F ₁	$\frac{3}{4}$ $\times$ $\frac{3}{4}$	$\frac{5}{8}$ $\frac{3}{4}$ $\times$ F ₁
At birth	n = 111 17.6 $\pm$ 0.6	n = 76 19.3 $\pm$ 1.8	n = 13 20.0 $\pm$ 1.8	n = 60 17.4 $\pm$ 0.9	n = 100 20.9 $\pm$ 0.6	n = 24 18.1 $\pm$ 1.5	n = 41 21.5 $\pm$ 0.8
3 months	n = 197 55.1 $\pm$ 1.5	n = 84 58.1 $\pm$ 2.0	n = 14 66.9 $\pm$ 4.8	n = 84 64.9 $\pm$ 2.8	n = 100 65.0 $\pm$ 2.2	n = 24 54.9 $\pm$ 4.1	n = 34 62.0 $\pm$ 4.5
6 months	n = 190 89.8 $\pm$ 2.5	n = 84 98.5 $\pm$ 3.1	n = 14 100.6 $\pm$ 8.1	n = 82 115.8 $\pm$ 3.9	n = 104 105.1 $\pm$ 3.2	n = 23 84.6 $\pm$ 5.6	n = 33 89.9 $\pm$ 5.3
12 months	n = 163 129.7 $\pm$ 3.6	n = 84 143.1 $\pm$ 5.1	n = 14 153.1 $\pm$ 10.2	n = 79 177.4 $\pm$ 4.9	n = 87 167.1 $\pm$ 5.1	n = 13 129.8 $\pm$ 14.4	n = 25 127.4 $\pm$ 8.0
18 months	n = 134 176.6 $\pm$ 5.4	n = 78 182.4 $\pm$ 6.1	n = 11 221.5 $\pm$ 9.7	n = 45 261.2 $\pm$ 6.1	n = 68 222.1 $\pm$ 5.7	n = 10 202.4 $\pm$ 23.7	n = 18 200.0 $\pm$ 13.3
2 years	n = 111 227.4 $\pm$ 5.5	n = 71 227.7 $\pm$ 8.0	n = 7 253.0 $\pm$ 11.0	n = 35 318.9 $\pm$ 10.2	n = 54 275.9 $\pm$ 8.0	n = 5 246.8 $\pm$ 50.2	n = 9 259.7 $\pm$ 16.0
3 years	n = 65 311.2 $\pm$ 10.1	n = 22 312.7 $\pm$ 16.4	n = 2 297.5	n = 22 395.6 $\pm$ 14.7	n = 28 378.8 $\pm$ 12.6		
4 years	n = 20 328.6 $\pm$ 18.8	n = 4 407.2 $\pm$ 3.8		n = 4 432.8 $\pm$ 23.3			

put out to graze either on the natural or improved savanna while calves of N'Dama cows or 3/8-bred cows were raised by natural suckling up to weaning at about 8 months of age. Calves from other crosses were separated from their dams at birth, fed colostrum, and were then subjected to a

standard feeding practice using whole milk, concentrates and hay; they were weaned at 4 months of age.

The weaners were grazed rotationally on night and day pastures of *Brachiaria ruziziensis*, *B. brizantha* or *Stylosanthes guianensis* and, in addition, were given a concentrate feed.

This phase, the most critical one, lasted, on an average, 4½ months. When the animals had reached 100-120 kg liveweight, they were included in the bull calf or heifer herds. Their feeding remained much the same at this stage, but the energy and protein supplement was restricted to 1 kg of

Jersey $\times$ N'Dama crossbred cow on *Panicum maximum* pasture.

TABLE 2. Liveweight gains (kg) of N'Dama and Jersey $\times$ N'Dama crossbred females

	N'Dama	F ₁	$\frac{3}{8}$ N'D $\delta \times \frac{3}{4}$	$\frac{3}{8}$ $\frac{3}{4} \delta \times$ N'D	$\frac{3}{4}$ J $\times$ F ₁	$\frac{3}{4}$ $\frac{3}{4} \times \frac{3}{4}$	$\frac{5}{8}$ $\frac{3}{4} \times$ F ₁
At birth	n = 119 16.7 $\pm$ 0.5	n = 69 17.7 $\pm$ 1.2	n = 15 17.4 $\pm$ 2.0	n = 50 16.1 $\pm$ 1.0	n = 90 20.5 $\pm$ 0.6	n = 12 17.5 $\pm$ 2.2	n = 49 20.4 $\pm$ 0.8
3 months	n = 198 5.14 $\pm$ 1.4	n = 78 55.0 $\pm$ 1.5	n = 9 61.4 $\pm$ 3.1	n = 77 61.6 $\pm$ 2.3	n = 93 62.8 $\pm$ 2.1	n = 12 51.3 $\pm$ 3.3	n = 48 60.9 $\pm$ 1.9
6 months	n = 189 84.3 $\pm$ 2.2	n = 75 94.2 $\pm$ 2.4	n = 9 90.8 $\pm$ 9.3	n = 75 108.1 $\pm$ 4.2	n = 107 102.3 $\pm$ 3.0	n = 12 78.5 $\pm$ 6.7	n = 48 87.0 $\pm$ 3.3
12 months	n = 158 120.7 $\pm$ 3.2	n = 75 137.9 $\pm$ 3.2	n = 9 131.6 $\pm$ 16.2	n = 73 165.2 $\pm$ 4.8	n = 101 158.2 $\pm$ 3.8	n = 6 121.5 $\pm$ 16.9	n = 33 128.8 $\pm$ 7.1
18 months	n = 139 154.2 $\pm$ 4.3	n = 74 185.4 $\pm$ 5.5	n = 9 191.3 $\pm$ 9.1	n = 53 225.5 $\pm$ 5.9	n = 94 212.8 $\pm$ 4.9	n = 6 179.0 $\pm$ 14.8	n = 23 192.7 $\pm$ 6.1
2 years	n = 128 190.9 $\pm$ 4.9	n = 70 216.7 $\pm$ 6.9	n = 8 235.9 $\pm$ 13.2	n = 47 257.0 $\pm$ 8.0	n = 81 258.3 $\pm$ 6.6	n = 3 157.0 $\pm$ 7.6	n = 12 240.8 $\pm$ 15.9
3 years	n = 44 259.8 $\pm$ 8.4	n = 40 308.4 $\pm$ 8.7	n = 6 276.0 $\pm$ 15.2	n = 31 306.6 $\pm$ 11.0	n = 58 287.9 $\pm$ 9.2		
4 years	n = 34 286.7 $\pm$ 8.4	n = 12 344.0 $\pm$ 16.9		n = 18 336.1 $\pm$ 10.8			

rice bran or cottonseed and given during the dry season only. Once the animals had reached 210 to 230 kg liveweight, they were incorporated in the herds of adult males and breeding cows.

The males were then subjected to more intensive feeding on improved pastures, with supplementary feeding during the dry season (1.5 kg of cottonseed or rice bran). In fattening trials, however, some of the animals were raised on intensively grown forage crops (irrigated *Panicum maximum*) from June 1973 to July 1974.

The females were maintained on *Stylosanthes* pasture from 1968 to 1971; from then on they had *Panicum maximum* available to them. In view of the uses to which they were to be put and their performance, the 3/8-bred cows were kept on natural or improved savanna. During milking, they consumed on an average 2 kg of rice bran as a supplementary energy source to the basic ration.

Preventive treatment was provided against contagious diseases such as rinderpest, bovine contagious pleuropneumonia and anthrax. Treatment for helminths and ticks was of the type that is standard in the Sudan-Guinean zone. No preventive or curative treatment was used against trypanosomiasis, except for the herd of 3/4-breds; for the latter, two annual injections of trypanidum were given until

1973, but thereafter a curative medication with Berenyl (N.D.) was given as required, the risks of infestation having diminished.

Performance

Liveweight gain. Owing to the nature of the experiment, animals of the various breeding groups could only be produced successively. Consequently it was not possible to make any contemporary comparisons of performance.

Comparisons were therefore limited to liveweight gains which are presented in Tables 1 and 2. It may be concluded that the 1/2-, 3/4- and 3/8-breds have very good rates of weight gain.

When the herds were maintained on irrigated pastures of *Panicum maximum* for one year, the 3/8-bred bull calves exhibited greater gains than did the 3/4-breds or the N'Dama (439, 409 and 355 g/day respectively).

In some of the breeding groups distinct differences appeared to be linked with the manner in which they were produced. The weight gain of the 3/8-breds obtained by mating 3/4-bred males to N'Dama females was superior to that of 3/8-breds from reciprocal matings. As for 3/8-bred bull calves obtained by the *inter se* mating of 3/8-bred parents, too little

data were available to make a comparison possible.

The progeny of *inter se* matings of 3/4-bred parents gave poorer results than the F₁. The maximum weights attained were 640 kg for 10-year-old F₁ draught oxen. F₁ cows are at present the heaviest of all crossbreds; the heterosis effect is particularly marked.

Productivity of females. The average age at first calving was 37 months for the N'Dama, 39 months for the F₁, 31 months in the 3/4-breds and 27 months in the 3/8-breds.

The 3/8-bred females appeared to be very precocious. Their age at first calving is on an average one year less than that of N'Dama females. This same aptitude did not appear in the F₁; however, the latter were bred at the age of 27 months on the basis of observations previously made among the N'Dama.

It may be noted that one 3/8-bred heifer that was accidentally mated at an early age did calve at 14½ months. Her calf, which she suckled, weighed 110 kg at 9 months. The rather extraordinary sexual precocity observed among the 3/8-breds confirms similar observations made elsewhere on Jersey crossbreds. This characteristic would serve the goal of increasing herd size rapidly and could be a useful trait in the humid tropics.

With adequate nutrition, it therefore seems perfectly feasible to obtain calving at the age of 24 months.

Average calving intervals were slightly less than one year for the various crossbred progeny. Compared with 410 days for the N'Dama, calving intervals among the F_1 , 3/4-breds and 3/8-breds averaged 355, 363 and 352 days respectively.

The maximum number of conceptions under natural mating conditions occurred at the end of the dry season for all animals, with the corresponding peak number of births in October, November and December.

Milk production. Almost all F_1 and 3/4-bred cows let down their milk even when their calves were not present at milking time. They also showed good aptitude for complete hand milking. On the other hand, there was great difficulty in hand milking the 3/8-breds; it is therefore concluded that these females should be kept as suckler cows, with the eventual possibility that some surplus milk may become available for sale.

Table 3 shows the milk yields of the F_1 and 3/4-breds in different lactations. Expressed as fat-corrected milk (FCM), the average milk yields (total and per day) of the F_1 increased progressively from the first to the sixth lactation (i.e., from 1 284 to 2 038 kg, which correspond to an average daily yield of 5 to 7.3 kg). The butterfat content was high; in the first lactation it was 5.76 percent, but declined thereafter to 5.47 percent in the sixth lactation.

The milk production of the 3/4-breds was on average higher than that of the F_1 . The yields increased substantially from the first to the fourth lactation (i.e., from 1 375 kg to 3 227 kg). The peak of the lactation curve was at the end of the first month. The persistency coefficient among the F_1 was 0.97 from the first to the second month and 0.92 from the second to the sixth month; thereafter, there was a drop to 0.87 in the seventh month and to 0.82 in the eighth and ninth months. Among 3/4-breds the corresponding figures were 0.96 during the first three months and 0.87-0.94 from the third to the

TABLE 3. Recorded milk production in halfbred and 3/4-bred animals

Lactation number	Level of upgrading	Number of observations	Length of lactation	Total milk yield	Butterfat content	Milk yield	Daily production
			Days	Kg	Percent	. . . Kg FCM . . .	
2nd	1/2	72	255	988	5.76	1 284	5.0
	3/4	53	263	1 136		1 375	5.2
1st	1/2	69	256	1 175	5.66	1 456	5.7
	3/4	23	287	1 332	5.36	1 603	5.5
3rd	1/2	59	255	1 271	5.59	1 569	6.2
	3/4	9	290	1 792	5.13	2 095	7.2
4th	1/2	36	251	1 435	5.52	1 749	7.0
	3/4	2	464	2 694	5.32	3 227	6.9
5th	1/2	10	268	1 611	5.44	1 942	7.2
6th	1/2	5	278	1 664	5.47	2 038	7.3

sixth month, depending on the length of the calving interval.

The average lactation period was 255 days among the F_1 . It was longer among 3/4-breds, in which group it varied from 263 to 464 days. The average length of the dry period was 100 days.

The highest milk yield recorded among the F_1 cows was 2 663 kg FCM in 276 days, corresponding to a daily average of 9.7 kg.

Behaviour of lactating cows. Seven F_1 cows had to be withdrawn from the dairy herds because they could not be hand-milked. They were placed in the N'Dama herd and used for selective breeding. This herd was kept under the most primitive conditions of the station, namely on natural or improved savanna.

The 3/4 N'Dama-1/4 Jersey calves obtained from these F_1 females showed markedly superior growth during the first six months to their N'Dama half-sibs (30 kg more for males and 36 kg more for females). Despite the limited number of progeny (five males and eight females), the difference is sufficiently great to be taken into account. The average daily milk yield during the first four months of lactation, estimated on the basis of the calf weight at four months of age, was 5.14 litres; this yield is close to that of the F_1 when milked by hand but kept under definitely better conditions.

F_1 and 3/4-bred cows thus had good milk yields and an aptitude for com-

plete hand milking, whereas the 3/8-breds had to be kept as suckler cows. Their performance is similar to that observed in Ghana.

Meat production potential. This was analysed almost exclusively on the F_1 males, since most of the 3/4-bred males had been used for reproductive purposes and the 3/8-bred males had been employed as draught cattle.

During intensive fattening trials the average daily gains observed on 37-month-old animals which grazed on *Panicum maximum* and received a concentrate ration (based on cottonseed and rice bran) were 896 g in the first month, 604 g in the second and 263 g in the third.

The carcass weights averaged 211 kg, with a dressing percentage of 57.8; the highest carcass weight was 241 kg, representing 61.3 percent of the live-weight. The conformation of the carcasses was generally good and the fat quality index satisfactory. The tender, juicy and finely marbled meat from these carcasses has always been greatly valued by consumers.

Health. The health of the F_1 and 3/8-breds under conditions at the CRZ, which was comparable to that among the N'Dama, was excellent. In particular, according to clinical observations they retained their trypanotolerance which is an essential quality of the N'Dama. Table 4 gives in summary form the percentage mortality recorded at the CRZ in each age class.



Jersey × N'Dama bullocks used for ploughing.

Among the 3/4-breds, however, mortality figures were particularly high, indicating that these animals are not very hardy. The main causes of death were rickettsiosis, pasteurellosis, trypanosomiasis, piroplasmosis and calf diarrhoea. The animals lost their trypanotolerance and after an initial observation period a wholesale treatment with trypamidium was practised. This was however discontinued in 1973 when the glossina became rare as a result of various measures taken at the station.

This general lack of hardiness of the 3/4-breds in all age-classes was attested by a poorer adaptation to the climate than that of the F_1 and 3/8-breds and caused, in particular, a reduction of their grazing period; the practice of not allowing the herds to go out except during the hotter hours of the day was catastrophic for the six 3/4-bred bulls loaned to local farmers. By contrast, in the same environment the F_1 and 3/8-bred steers gave complete satisfaction; the few deaths reported were attributable

not to lack of hardiness among the animals but to accidents or to a lack of minimal care and to inadequate nutrition.

Conclusions

The overall balance is very favourable for the F_1 and 3/8-bred Jersey × N'Dama crosses. The 3/4-breds, however, lack hardiness, and this limits their potential future use in the humid tropics.

The 3/8-breds would do perfectly well under the care of trained stockmen. Their hardiness, their suitability as draught animals, their high growth rate — definitely superior to that of the N'Dama — along with their sexual precocity (making calving possible at slightly over two years of age), the eventual possibility of partial milking (a difficult habit to change, because it is the regular source of income from most local herds and would result in catastrophic consequences for the calves) should make 3/8-breds the choice animals in a general pro-

gramme for rapid development of meat production. Moreover, considering its ease of calving, this type of animal could be used as the stock for a more ambitious genetic upgrading programme. Nevertheless care has to be taken not to reach the 3/4-bred level.

In making a summary report on overall performance the F_1 could be readily ranked as the best; it combines hardiness and high liveweight, good carcass quality, excellent aptitude for use as a draught animal, and a good milk yield, with the possibility for complete hand milking. This type of animal should be popularized among middle-size farms that practise a minimum of intensive production of forage and fodder crops, and also among suburban improved stock farms which have trained manpower at their disposal and which market their milk. F_1 females are, in fact, capable of giving a gross monetary value seven times greater than N'Dama cows and have much better fitness characteristics; the males are choice beef or draught animals. In any case, extreme prudence in selecting a breeding programme is essential. The results obtained for the 5/8-breds are still too incomplete to recommend production of this type of animal, and the risk of segregating genetic traits by crossbreeding of the F_1 has not been assessed, so further experimentation is needed. Other genetic avenues that permit maximum benefits from heterosis, such as two-stage crossing and rotational crossing, re-

TABLE 4. Percentage of mortality in different breed groups

	3/8	F_1	5/8	3/4	N'Dama
	Percent				
Bull calves and heifers	5	7.6	22	28.6	8
Yearlings and 2-year-olds	3	4.3	4.6	14.2	
2-year-olds to 3-year-olds	1	1		16.8	
Adult cows		2		16.2	
Bulls				3.2	

main to be explored, but it would be worth while seeking out parent stock adapted to the tropics.

Under present conditions, the production of 3/4-breds is not recommended; indeed, it is to be avoided. Commercial crossbreeding, involving the slaughter of F_1 females, is also not advised, because this would be contrary to the important policy of increasing herd size. The use of F_1 animals for breeding should be looked at in relation to the end use of the progeny. If they are to remain in the farm sector, backcrossing to the N'Dama may be recommended; the resultant animals exhibit excellent hardiness and are superior in performance to the N'Dama.

The mating of 5/8-bred bulls with F_1 females probably presents the minimum risks for medium-sized enterprises or dairy farms on the outskirts of towns with trained manpower and improved pastures. A return to a policy of two-stage crossing might also be considered, provided that the greatest caution is exercised in the choice of the third breed which would, in any case, be of minimum hardiness. The 3/4-breds are not to be recommended in the various production settings.

The question that remains is: what policy should be adopted for a large-scale crossbreeding programme in the humid tropics in the light of these ten years of experience with Jersey $\times$ N'Dama crossbreeding in Ivory Coast?

Apart from the necessity of carefully identifying the best stock farming areas, ascertaining the level of technical knowledge of stock farmers, and investigating possibilities for intensive production of forage and fodder crops and for using agro-industrial by-products as feed, it is important to adopt an appropriate method for reproduction, whether it be natural mating or artificial insemination. Widespread natural mating is only feasible with 3/4-bred bulls on N'Dama cows or 5/8-bred bulls on F_1 cows, while the production of 3/4-bred bulls should be organized in specialized centres prior to their use in a few stud farms, where the sires would be under close surveillance. This could be facilitated by a well-controlled

lending scheme to herds run by trained stockmen in favourable regions, in particular, in natural savanna regions with heavy soils where draught animals are used, or in stock farming regions where trained stockmen are implementing a forage improvement programme. The use of 5/8-bred bulls in medium-sized enterprises or in suburban stock farms with trained manpower and improved pastures presents much less difficulty.

Recourse to artificial insemination does not seem a utopian dream and is favoured by the current practice of community raising of large herds. In any case, two prerequisites, at present the subject of research, should be mentioned: a good knowledge of the sexual physiology of local humpless cattle, and the development of artificial insemination techniques through oestrus synchronization.

Whichever method of reproduction

is chosen, extension work to popularize a policy of crossing requires the establishment of specific breeding facilities, such as a centre for multiplication of sires with a high percentage of Jersey blood (over 50 percent), a stud farm, and an artificial insemination centre.

The establishment of such facilities is largely a prerequisite for the popularization of the Jersey $\times$ N'Dama cross, which offers the potential of a 50 percent increase in meat production as compared with the local N'Dama cattle. Taking also milk yield into account, the gross production value of each half-bred cow could be increased fivefold and the enormous forage potential of the countries in the humid tropics could be utilized profitably. Moreover, the maternal qualities of F_1 and 3/8-breds open the way to more ambitious genetic programmes. ■

References

- CHARRAY, J. 1975. *Bilan des abattages de bœufs N'Dama réalisés au C.R.Z. de Minankro de mars 1974 à mars 1975. Etude des carcasses*. C.R.Z. de Bouaké-Minankro. 4 p. (Mimeographed)
- COULOMB, J. 1967. *Sélection des taureaux de race N'Dama au C.R.Z. de Minankro 1956-1966*. I.E.M.V.T. 65 p. (Mimeographed)
- COULOMB, J., RIVIÈRE, PAGOT, J. & CABOT. 1971. *Métissage Jersiais-N'Dama. Résultats obtenus au Centre de recherches zootechniques de Bouaké-Minankro*. 1ère note. I.E.M.V.T. 68 p. (Mimeographed)
- GLATTLEIDER, L. 1974. *Note sur la valeur alimentaire des fourrages tropicaux. Premiers résultats sur Panicum maximum K 187 B*. C.R.Z. de Bouaké-Minankro. 18 p. (Mimeographed)
- GOMBAUD, B. 1973. *Engraissement de bœufs N'Dama de 4 ans en stabulation et sur pâturage permanent complétement*. C.R.Z. de Bouaké-Minankro. 53 p. (Mimeographed)
- IVORY COAST. CENTRE DE RECHERCHES ZOOTECHNIQUES. *Annual reports, 1965 to 1974*.
- JOUE, J.L., LETENNEUR, L. & CATALA, P.E. 1971. *Mise en place d'un élevage d'embouche en secteur paysan. Résultats après 1 an d'expérience*. C.R.Z. de Minankro-Bouaké. 47 p. (Mimeographed)
- JOUE, J.L. & LETENNEUR, L. 1972. *Essai d'embouche intensive de taureaux Jersey-N'Dama en Côte d'Ivoire*. *Rev. Elev. Méd. vét., Pays trop.*, 25(2): 309-316.
- LETENNEUR, L. 1973. *Production fourragère en Côte d'Ivoire et possibilités d'intensification*. 58 p., 42 tables.
- MESSAGER, J.L. & LETENNEUR, L. 1972. *Un exemple de production fourragère intensive. Observation sur l'exploitation au pâturage du Panicum maximum*. 45 p.
- PAGOT, J., COULOMB, J. & PETIT, J.P. 1972. *Revue et situation actuelle de l'emploi des races trypanotolérantes. Rapport au séminaire inter-régional FAO/OMS sur la trypanosomiase africaine, Kinshasa, 23 octobre-3 novembre 1972*.
- RALAMBOFIRINGA, A. 1975. *Contribution à l'étude de la physiologie de la reproduction, la méthodologie de la détection de l'œstrus et la technologie de l'insémination artificielle de la vache N'Dama en République de Côte d'Ivoire*. Toulouse. (Thesis)

Current situation and outlook for animal feeds and animal products*

□ CEREALS

Early prospects for the 1978 wheat and coarse grain crops are mostly favourable. Delays in spring sowing are causing some concern in parts of North America, northern Europe and the U.S.S.R. FAO currently forecasts a world wheat harvest of 405 million tons, 20 million tons above last year's below-average crop. Coarse grain production in 1978 is expected to be as large as in the previous year.

The regional production outlook data available at FAO indicate that larger wheat and coarse grain crops than last year are estimated for 1978 in all regions except North America, where plantings were reduced reflecting the introduction of United States policies to reduce output, and also in Latin America because of the drought which has affected the maize crop in Brazil.

In Europe the overall condition of winter cereals is satisfactory and a larger wheat crop is anticipated; in view of the good soil moisture conditions in most parts of the continent a coarse grain crop above last year's is tentatively forecast.

FAO forecasts U.S.S.R. grains production (including rice and pulses) at 215 million tons in 1978, 10 percent above the 196 million ton harvest of 1977. The official 1978 production target is 220 million tons, but it is unlikely to be reached.

Production in developing

countries is expected to increase by 6 percent, reflecting better wheat and coarse grain prospects in the Far East, Near East, Africa, and parts of Latin America.

stantially from this early forecast if production in some major importing countries were to deviate from current expectations.

If current production and

the reserve stock accumulation has restricted the supply of "free" stocks available on the market. As compared with a year earlier, grain prices are substantially higher: 35 percent more for wheat and 12 percent for maize and sorghum.

World wheat and coarse grains production

	1976	1977	1978 forecast	Change 1978 forecast over 1977
	 Million tons			Percent .
Wheat	418	375	405	+5
Coarse grains	704	705	704	—
Total	1 122	1 090	1 109	+2

World trade in grains is estimated by FAO to reach 142 million tons during the current 1977/78 season, nearly equally divided between wheat and coarse grains. Developing countries accounted for some two thirds of the wheat imports and for one quarter of the coarse grain imports.

Any attempt now to forecast international trade in grains in 1978/79 must be regarded as very tentative since cereal production in importing and exporting countries is still uncertain. On the basis of a preliminary evaluation, FAO forecasts wheat imports in 1978/79 at 64 million tons and those for coarse grains at 71 million tons. Total trade in wheat and coarse grains, at 135 million tons, is thus forecast to be smaller than in 1976/77 and 1977/78. However, the actual size of international trade in grains in 1978/79 could differ sub-

stantially from this early forecast if production in some major importing countries were to deviate from current expectations. If current production and trade forecasts materialize, world wheat and coarse grains carry-over stocks at the end of the season would not change significantly from those expected for this year. An important element in the current situation is the low level of stocks in most developing countries and the unusual concentration of supplies in the United States. This country is forecast to hold this year 45 percent of the world carry-over stock (excluding the U.S.S.R. and China), against 38 percent a year earlier. A large portion of the U.S. stocks will be temporarily off the market, kept in the farmer-owner reserve, from where supplies will be released only when farm prices reach predetermined levels. The rapid accumulation of wheat in the U.S. farmer-owner reserve has probably been the most important factor in the recent strength in grain prices since

□ OILSEEDS, CAKES AND MEALS

World production prospects for oilseeds, fats and oils in the current 1977/78 season have deteriorated slightly in recent weeks although, overall, global production is still expected to remain in excess of demand and to allow some stock rebuilding.

The somewhat lower world output forecast reflects mainly the drought which has adversely affected soybean yields in some producing states of Brazil. Contrary to earlier expectations, the Brazilian crop this year will be smaller than in 1977, but opinions differ as to the extent of the reduction. Exports of soybeans are already subject to some regulation by the Brazilian authorities. In Argentina excessive rainfall is reported to have caused losses in groundnut and sunflower seed crops. On the world demand side, the main uncertainty remains the possibility of additional purchases of soybean and/or products by the U.S.S.R. and China.

World markets will in future months be increasingly influenced by supply prospects for annual crops to be harvested in the second half of 1978. U.S. farmers' planting

* As of 22 May. Source: FAO Commodities and Trade Division.

intentions (as of 1 April) indicate a record 25.8 million hectares under soybeans, 8 percent more than in 1977.

Largely reflecting possible changes in supply prospects, international market prices in oil meals have firmed in recent months though the values for cakes and meals are still 15-30 percent below the exceptionally high levels reached a year ago.

The price situation in coming months will continue to be affected by the final outcome of South American crops and by developments in import demand from China, India and the U.S.S.R. but, increasingly, the most important factor will be the prospects for annual oilseeds to be harvested later this year and for oil and oilseed crops in early 1979. At present, the prospects for next season suggest the possibility of a significant expansion in output in some major producing and exporting countries.

□ MILK AND MILK PRODUCTS

World milk production, which had risen by about 3 percent in 1977, has so far slowed down this year to a rate of 2 percent. This reflects a deterioration in the feed situation, notably in the U.S.S.R., eastern Europe and Australia, and some rise in concentrate feed prices on North American markets, as well as policy measures to curb excess milk production in several developed countries.

The slow-down has not been general in all countries. In the EEC, the world's largest producer, the growth rate was still some 3 percent during the first quarter of this year, but in the U.S.S.R. and eastern Europe it fell below 2 percent — only half the rate of increase in the calendar year 1977. In the United States the expansion has virtually come to a halt in recent months, and output in Australasia has increasingly lagged behind year-earlier levels; pro-

duction in the developing countries too has shown little increase. Only in Japan has there been a further marked rise.

The medium-term outlook is for a further slow-down. The historical decline in western European and North American dairy cow numbers which had almost come to a halt in recent years appears to have accelerated again this year. In North America marked increases in slaughter cattle prices, the extent of which has substantially exceeded the rise in the milk support prices fixed by the governments of both Canada and the United States as of 1 April 1978, are expected to lead to greater culling of dairy cows. Some northwestern European countries are also pursuing or intensifying their policies to curb excess milk production. In the EEC, where farmers' response to the 1977/78 dairy cow reduction programme was well below earlier expectations, the scheme has been extended, and premiums to encourage farmers to give up commercial milk production have been increased. While the decrease in North America and western Europe in dairy cow numbers should be offset by further rises in yields, improvements are unlikely to repeat the exceptional pace of growth registered last year. In the U.S.S.R. and eastern Europe, dairy cow numbers have risen and, if grazing conditions are normal this summer, the expansion of milk output could accelerate again.

Notwithstanding the slower growth of global production, world milk output will continue to exceed commercial demand. In most developed countries demand for milk and milk products as a whole is levelling off.

Although exports to developing countries, notably OPEC countries, are likely to grow further, the stocks of dairy products will remain burdensome.

□ MEAT

The increase in 1978 world meat production may be smaller than forecast earlier. Poultry production is still expected to increase slightly, but a lower increase in pigmeat production appears likely. Sheepmeat production is expected to remain at around last year's level, but supplies of beef, which declined in 1977 for the first time since 1973, are likely to be further reduced in 1978.

In the United States, the world's leading producer, beef production in the first quarter of 1978 was 3 percent lower than in the same quarter of 1977 and 6 percent lower than in the first quarter of 1976. As demand has been strong, prices of beef, notably manufacturing beef, have risen considerably. Production for the remainder of 1978 is forecast to remain below production in the corresponding period last year. With favourable feed prices there has been a substantial increase in the number of cattle sold for intensive feeding in feedlots. Furthermore, as a result of good pasture conditions in most parts of the country and because of the reduction in stock numbers of recent years, supplies of less intensively fed cattle were short in the first quarter of this year. This shortage will accentuate with increased retentions for breeding. The resultant higher wholesale and retail prices may lead to pressure to relax meat import restrictions. Under the present voluntary restraint agreements (Meat Import Law), meat imports have been negotiated at approximately 590 000 tons (product weight) for 1978, only 2 percent more than last year.

The EEC appears unlikely to raise its beef imports substantially in 1978, although beef prices have also risen in this market in recent months, with average cattle market prices exceeding the level of the intervention price for the

first time since the mid-1970s. However, in view of the rise in the 1978/79 guide price by 2.5 percent, the levy on regular imports will remain high, and actual purchases will probably not significantly exceed the level of the various quotas for imports on preferential terms, particularly as EEC beef intervention stocks remain at over 0.3 million tons.

Canada and Japan have set somewhat higher beef import quotas for 1978. Canada's import limitation agreements for fresh, chilled and frozen beef and veal allow imports from the United States, Australia and New Zealand of 67 000 tons product weight — 1 000 tons more than in 1977. Japan has announced its general import quota for the first half of 1978/79 fiscal year (April to September) of 40 000 tons, compared with 35 000 tons in the first six months of the 1977/78 fiscal year. However, even allowing for an increase in Japanese imports during the second half of the fiscal year, total beef import quotas of the four major traditional importers (United States, Canada, EEC and Japan) at approximately 1.0 million tons would be only slightly larger than last year.

The importance of non-traditional import markets, particularly the U.S.S.R., eastern Europe and the Near East, has increased sharply since 1973. In 1978, however, with the build-up in herds in the U.S.S.R. and eastern Europe, meat output should continue to grow in these countries, and import requirements are likely to be lower.

On the export side, reduced beef production is forecast, especially for Australia and New Zealand. However, the decline in output could be partly offset by lower domestic consumption and by a reduction of stocks. Since the end of 1977 there has been a considerable increase in beef import prices in the U.S. market. ■

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